USER'S MANUAL 990-143
Revision C July 2010

OPERATOR MANUAL

FOR THE

SERIES 70 WELD HEADS

MODEL NUMBER	STOCK NUMBER
71	2-240-01, 2-240-02, 2-240-02-02
72	2-241-01, 2-241-02, 2-241-02-02
73	2-244-01

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Revision Record

Revision	EO	Date	Basis of Revision
A	20183	11/04	None. Original edition.
B	21776	5/08	Update to Miyachi Unitek logo, and added new **CAUTION** information.
C	40496	7/10	Addition of Series 73 models.

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CONTACT US

Thank you for purchasing a Miyachi Unitek™ Series 70 Weld Head.

Upon receipt of your equipment, please thoroughly inspect it for shipping damage ***before*** installing it. If there is any damage, please contact the shipping company immediately to file a claim, ***and*** notify Miyachi Unitek at:

1820 South Myrtle Avenue
P.O. Box 5033
Monrovia, CA 91017-7133

Telephone: **(626) 303-5676**

FAX: **(626) 358-8048**
e-mail: **Info@muc.Miyachi.com**

The purpose of this manual is to provide the information required for proper and safe operation and maintenance of the Series 70 Weld Heads.

We have made every effort to ensure that information in this manual is both accurate and adequate. If you have any questions or suggestions to improve this manual, please contact us at the phone number or addresses above.

Miyachi Unitek Corporation is not responsible for any loss or injury due to improper use of this product.

SAFETY PRECAUTIONS

Before using this equipment, read the **SAFETY PRECAUTIONS** carefully to understand the correct usage of the equipment.

- These precautions are given for safe use of the Inverter Weld Head and for prevention of injury to operators or others.
- Be sure to read each of the instructions, as they are all important for safe operation.
- The meanings of the words and symbols are as follows:

⚠ WARNING

Denotes operations and practices that may result in serious injury or loss of life if not correctly followed.

⚠ WARNING

Denotes operations and practices that may result in serious injury or loss of life if not correctly followed.

⚠ CAUTION

Denotes operations and practices that may result in personal injury or damage to the equipment if not correctly followed.

These symbols denote **PROHIBITION.** They are warnings about actions that should ***not*** be performed because they can damage the equipment and will void the warranty.

These symbols denote actions which operators ***must*** take.

Each symbol with a triangle denotes that the contents gives notice of **DANGER, WARNING,** or **CAUTION** to the operator.

⚠ DANGER

NEVER DISASSEMBLE, REPAIR, OR MODIFY THE WELD HEAD.

These actions can cause electric shock and fire. Do ***not*** do anything other than the maintenance described in this manual.

WARNING

Do NOT put your hands or fingers between the electrodes.

When welding, keep your hands and fingers away from the electrodes.

Do NOT touch any welded part or electrode during, or just after welding.

The welded parts and electrodes are very ***hot***. If you touch them you will be burned.

Only use specified cables.

A cable with insufficient capacity or loose connections can cause electric shock or fire.

Only apply the specified power.

Application of a voltage or current out of the specified range can cause electric shock or fire.

Do NOT use a damaged connecting cables, or plugs.

Do ***not*** step on, twist, or tense any cable. Connecting cables may be damaged which can cause electric shock, short circuit, or fire. If any part needs to be repaired or replaced, consult Miyachi Unitek or your distributor.

Stop operation if any trouble occurs.

If you detect a burning smell, abnormal sounds, abnormal heat, smoke, etc., turn power OFF immediately to prevent fire or electric shock. Contact Miyachi Unitek or your distributor for help.

People with pacemakers MUST stay away from the Weld Head.

When the Weld Head is operating, it generates a magnetic field, which adversely affects pacemakers. People who use a pacemaker must ***not*** approach the Weld Head, or walk around the welding shop while the Weld Head is operating, ***unless*** their medical doctor has deemed it safe to do so.

Wear protective gear.

Put on protective gear such as protective gloves, long sleeved jacket, and leather apron to avoid being burned.

CAUTION

Keep water and water containers away from the Weld Head.

Water spilled on the Weld Head can cause a short circuit, electrical shock, or fire.

Use proper tools (wire strippers, pressure wire connectors, etc.) for terminations of the connecting cables.

Do ***not*** nick the wire conductor. Doing so can cause a short circuit, electric shock, or fire.

Do NOT damage connecting cables or connectors during use.

Do ***not*** step on, twist, or tense any cable. Connecting cables may be damaged which can cause electric shock, short circuit, or fire. If any part needs to be repaired or replaced, consult Miyachi Unitek or your distributor.

Install the Weld Head on a firm, level surface.

Injury may result if the Weld Head falls over or drops from an uneven surface.

Keep combustible matter away from the Weld Head.

Spatter can ignite combustible materials. If you cannot remove all combustible materials, cover them with a non-combustible material.

Do NOT cover the Weld Head with a blanket, cloth, etc.

Heat generated by the operating Weld Head may ignite a blanket or cover.

Wear ear protectors.

Loud noises can damage hearing.

Keep a fire extinguisher nearby.

Make sure there is a fire extinguisher in or near the welding shop in case of fire.

Regularly inspect and maintain the Weld Head.

Regular inspection and maintenance is essential to safe operation and long life of the equipment. If you see any damage, make necessary repairs before operation.

Installation Precautions

Do ***not*** install this Welding Head in ***any*** of the following:

- Damp places where humidity is 90% or higher.
- Dusty places.
- Places where chemicals are handled.
- Places near a high-frequency noise source.
- Hot or cold places where temperatures are above 40°C or below 0°C, or places where water will condense.

CAUTION

Do ***not*** modify the electrode holders or attach additional mechanisms to the moving parts of the head. Doing so may hurt welding performance, damage the head, and ***void the warranty***.

Operating Precautions

- Do ***not*** put anything other than a workpiece (tool, screw, coin, etc.) between the electrodes or on the Weld Head or you may damage the Weld Head or cause a short circuit or fire.
- Operate the Welding Head ***only*** according to the instructions in this manual.
- Operate the button carefully ***by hand***. If it is operated roughly or with the tip of a tool you may damage the Weld Head.

Disposal Precaution

The Motor Controller photo-coupler contains **GaAs**. Follow ***all*** local environmental regulations for disposal.

CE

MIYACHI TECHNOS CORPORATION

EC Declaration of Conformity

The company/manufacturer: Miyachi Technos Corporation
95-3, Futatsuka, Noda-City, Chiba, 278-0016 JAPAN

Herewith declares conformity of the products

Designation: Resistance Welding Head
Type/Serial Number, etc: MH-P20A / MH-D20A

With applicable regulations below

EC Directive: Machinery Directive 98/37/EC amended by:
89/392/EEC,91/368/ECC,93/44/EEC and 93/68/EEC

Low voltage Directive 73/23/EEC amended by:
93/68/EEC

EMC Directive 89/336/EEC amended by:
91/31/EEC and 93/68/EEC

Harmonized European Standards applied:

EN 55011(Group 2, Class A):1991; EN 60204-1:1998;
EN 61000-4-2:1995(contact: level 3, air discharge: level 3);
EN 61000-4-3:1995(level 2);
EN 61000-4-4:1995(power line: level 3, signal line: level 3);

Importer Distributor in EU: MIYACHI TECHNOS EUROPE GmbH
Pleidelsheimer Strasse 11,D-74321 Bietigheim, Germany

Division:
Japan / Noda-City

Miyachi Technos Corporation
M.Hasegawa / Director,Production

Oct.02.2003
Place and Date

Name/Signature/Position

Note: This Declaration certifies conformity with the above mentioned Directives, but gives no assurance of properties within the meaning of the Law concerning product liability.
It becomes invalid if any technical or other modifications are carried out without manufacturers consent.

CHAPTER 1
DESCRIPTION

Section I: Features

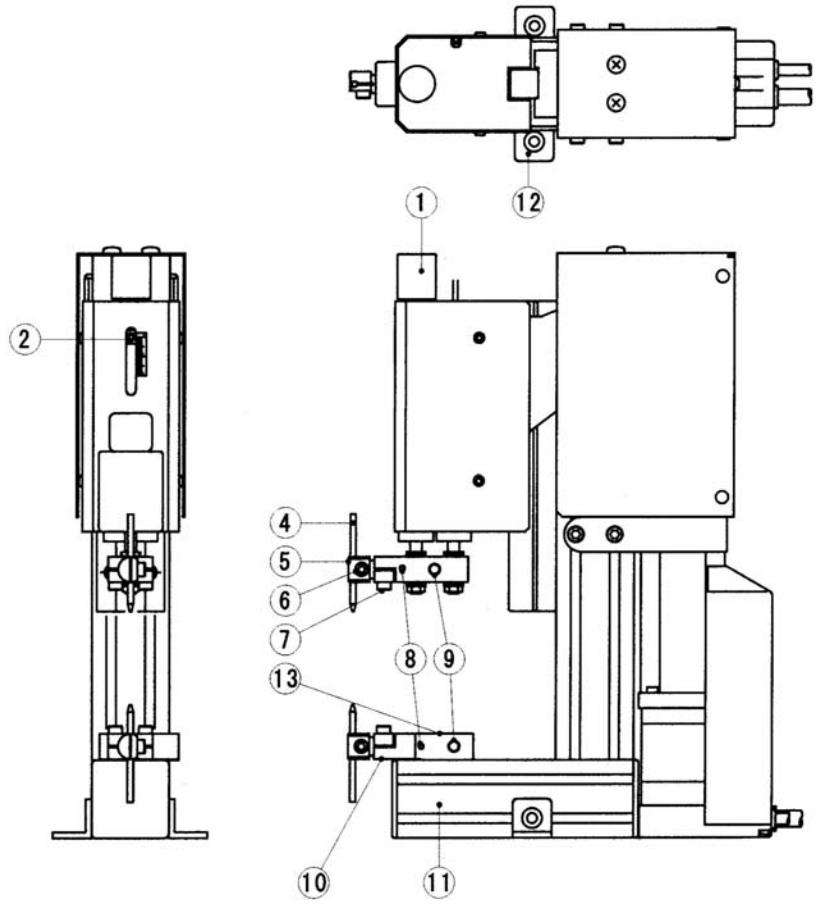
For the rest of this manual, **Series 70 Weld Heads** will simply be referred to as the ***Weld Head***. The **Motor Control Unit** will simply be referred to as ***The Controller***.

The Weld Head has the following features:

- Owing to motor-driven mechanism, the electrode force is always stable, even if the part thickness changes. No fine gap adjustment is necessary when replacing electrodes.
- The electrode force is 1-8 lbs per electrode for the Model 71 and 72 Weld Heads.
- The electrode force is 15-110 lbs per electrode for the Model 73 Weld Head.
- You can adjust the electrode speed to suit your welding needs. The force is adjustable in four steps; the electrode-up/down speed, in eight steps.
- You can manually or externally select thirty-one different weld schedules.
- The electrode moves down quickly from the start point (stand-by position) to the mid-point (middle-stop position); then slowly to contact the workpiece.
- The speed of the electrode can be programmed so as not to cause excessive impact to the parts.
- The start point and the mid-point are adjustable arbitrarily.
- The electrode moves up and down between the mid-point and workpiece for continuous welding. This reduces the weld cycle time as the electrode doesn't need to return to the start point every time it welds. This can be useful in automation.
- During welding, the workpiece can expand and shrink. This Weld Head employs a spring so that the electrode can follow-up the deformation of the workpiece quickly which reduces splash.
- The dedicated Controller easily sets the electrode position and speed.
- Since this Welding Head is motor driven, the piping for air actuation is not needed, enabling an easy installation.

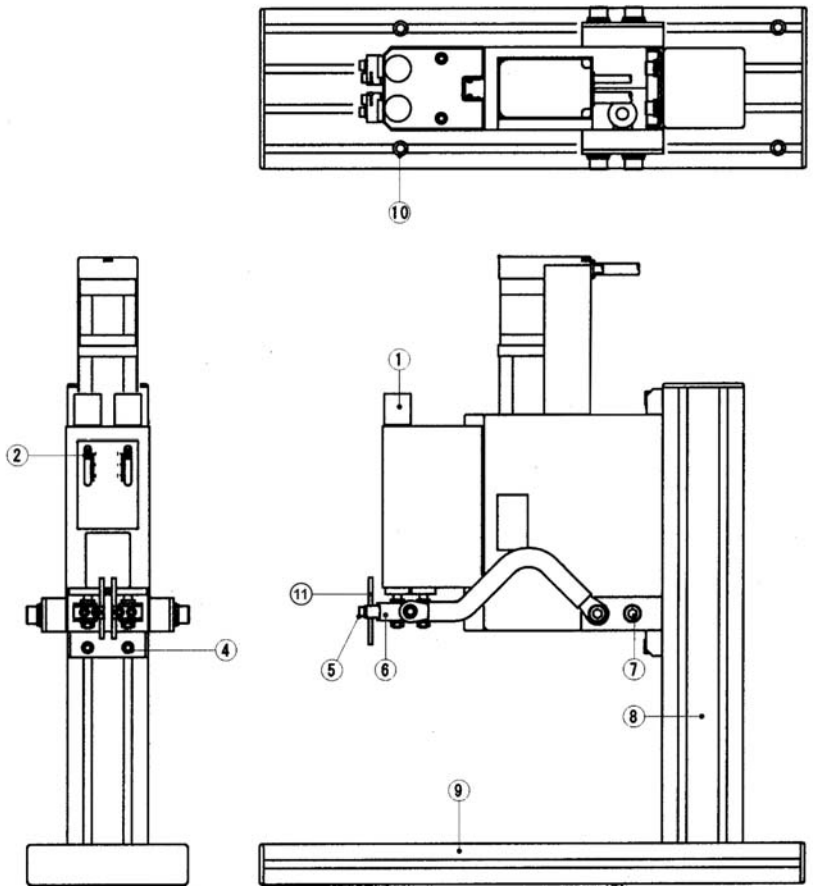
Section II: Major Components

Model 71 Weld Head



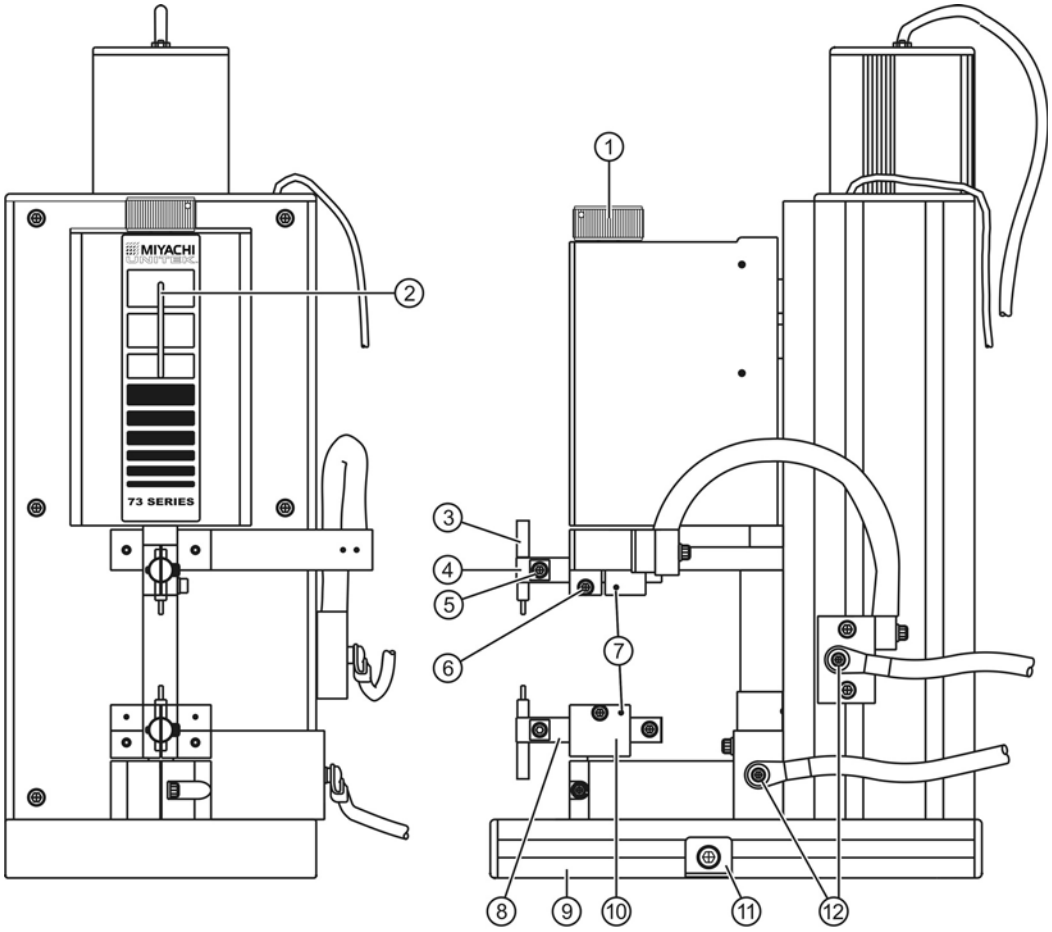
Item	Name	Description
1	Weld Force Adjustment Knob	Adjusts the electrode force.
2	Lock Screw	Locks the Weld Force Adjustment Knob.
4	Electrode	For spot welding.
5	Electrode Holder	Holds the electrode.
6	Electrode Screw	Secures the Electrode to the Electrode Holder.
7	Holder Clamping Screw	Clamps the Electrode Holder in place.
8	Voltage Sensing Cable Screw	Connects the Voltage Sensing Cable.
9	Weld Cable Screw	Secures the Weld Cable to the Electrode Holder Adapter.
10	Electrode Holder Adapter	Connects the Electrode Holder to the head.
11	Base	Supports the Mounting Post.
12	Head Bracket	For mounting the Weld Head to the work bench. Two brackets are provided, each with 2/10” (5.5mm) mounting holes.
13	Adapter Mounting Screws	Secures the bottom Electrode Adapter to the Base.

Model 72 Weld Head



Item	Name	Description
1	Weld Force Adjustment Knob	Adjusts the electrode force.
2	Lock Screw	Locks the Weld Force Adjustment Knob.
3	N/A	N/A
4	Mounting Screw	Secures the Head to the Mounting Post
5	Electrode Screws	Secures the Electrodes to the Holders.
6	Voltage Sensing Cable Screw	Connects the Voltage Sensing Cable.
7	Weld Cable Screw	Secures the Weld Cable to the Power Bar.
8	Mounting Post.	Attaches to the Base and supports the Weld Head.
9	Base.	Supports the Mounting Post.
10	Base Mounting Holes.	For mounting the Welding Head on the workbench. Six (6) holes are provided. Each hole is ¼-inch (6.5mm), with Ø.43-inch (11mm) spot facing, and Ø.4-inches (10mm) deep.
11	Electrodes	For spot welding.

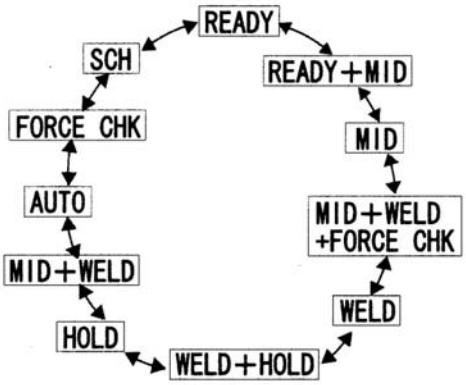
Model 73 Weld Head

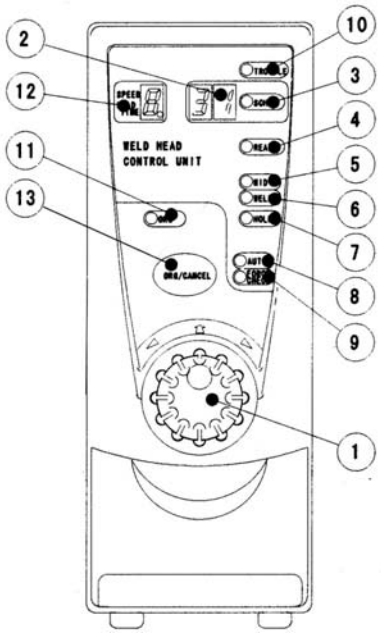


Item	Name	Description
1	Weld Force Adjustment Knob	Adjusts the electrode force.
2	Lock Screw	Locks the Weld Force Adjustment Knob.
3	Electrode	For spot welding.
4	Electrode Holder	Holds the electrode.
5	Electrode Screw	Secures the Electrode to the Electrode Holder.
6	Holder Clamping Screw	Clamps the Electrode Holder in place.
7	Voltage Sensing Cable Screw	Connects the Voltage Sensing Cable.
8	Electrode Holder	Holds the electrode.
9	Base	Supports the Mounting Post.
10	Electrode Holder Adapter	Connects the Electrode Holder to the head.
11	Head Bracket	For mounting the Weld Head to the work bench. Two brackets are provided, each with 2/10” (5.5mm) mounting holes.
12	Weld Cable Screw	Secures the Weld Cable to the Electrode Holder Adapter.

Controller (Front Panel)

Operation Button. You operate the Weld Head by turning the button clockwise/counterclockwise and by pressing it. By turning the button, the lamp illumination changes as shown below.





Lamp	When Illuminated,	When blinking,
AUTO Lamp	Operation button is selecting a function.	Auto-function will set electrode position and movement.
FORCE CHK Lamp	Operation button is selecting a function.	Weld force can be measured.
HOLD Lamp	Operation button is selecting a function.	Hold Time can be changed.
MID Lamp	Electrode is at Mid-Point. Operation button is selecting a function.	Mid-Point can be changed.
ORG Lamp	The **ORG** Lamp is not used.	
READY Lamp	Electrode is at Start Point and completed for work. Operation button is selecting a function.	Start Point can be changed.
SCH (Schedule) Display	Schedule Nos. are displayed. (There are 31 combinations of Electrode position, Speed and Hold Time that can be registered as Schedules in the 70 series.	When power supply is applied, zero "0" blinks. When trouble occurs, fault code is displayed. Weld force can be measured
SCH (Schedule) Lamp	Operation button is selecting a function.	Schedule No. can be changed
TROUBLE Lamp	Trouble is occurring.	
WELD Lamp	Electrode is at Weld Point. Operation button is selecting a function.	Lowest point (Downstop Point) is being changed.

SPEED HOLD TIME Display

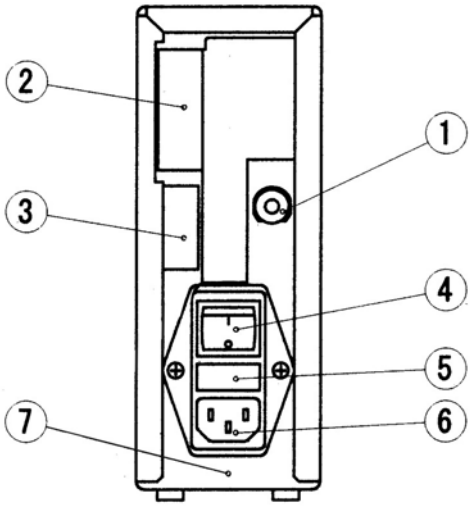
Indicates the "electrode speed" and "**HOLD** Time after the application of weld force is completed." The larger number indicates the faster electrode speed and the longer **HOLD** time.

The lamp lights up simultaneously with other lamps as shown below.

Lamp	When illuminated,	When blinking,
READY Lamp and MID Lamp and SPEED HOLD TIME Display	Operation button is selecting a function. (**SPEED HOLD TIME** Display does ***not*** light up.) Electrode is moving between Start Point and Mid-Point.	Electrode speed between Start Point and Mid-Point can be set.
MID Lamp and WELD Lamp and SPEED HOLD TIME Display	Operation button is selecting a function. (**SPEED HOLD TIME** Display does ***not*** light up.) Electrode is moving from Weld Point to Mid-Point.	Electrode speed from Weld Point to Mid-Point can be set.
MID Lamp and WELD Lamp and FORCE CHK Lamp and SPEED HOLD TIME Display	Operation button is selecting a function. (**SPEED HOLD TIME** Display does ***not*** light up.) Electrode is moving from Mid-Point to Weld Point.	Electrode speed from Mid-Point to Weld Point can be set.
WELD Lamp and HOLD Lamp and SPEED HOLD TIME Display	Operation button is selecting a function. (**SPEED HOLD TIME** Display does ***not*** light up.)	The desired time for which the additional weld force is exerted on after applying the weld force at Weld Point is being set.
HOLD Lamp and SPEED HOLD TIME Display	Operation button is selecting a function. (**SPEED HOLD TIME** Display does ***not*** light up.)	Hold Time can be set.
SPEED HOLD TIME Display	In case of Movement Mode 1, electrode position is at Start Point and the Display shows "A' when setting is not performed.	

ORG/CANCEL Button. This button interrupts the programming changes in progress.

Controller (Rear Panel)



Number	Name	Description
1	**MOTOR CONTROL Connector**	Connects the control motor to drive the electrode.
2	**I/O Connector**	Used for input/output signal connections.
3	**Weld Force Detecting Sensor Connector**	Connects the Weld Force signal from the welding head.
4	**Power Switch**	Turns the Controller ON/OFF.
5	**Fuse Holder**	Fuse Rating 250V, 1A, 5mm diameter, 20mm length (Slow Blow melting and high breaking capacity type).
6	**Power Supply Connector**	Used for connecting a power supply cable (separately sold) to 100 to 240 VAC power supply.
7	**Ground Terminal**	Used as a ground terminal when you are ***not*** using a power supply cable with a ground wire (sold separately).

CHAPTER 2
INSTALLATION AND SETUP

Section I: Installation

Unpacking

The Weld Head comes fully assembled from the shipping box. The only installation requirements are planning the workspace, installing the electrodes, and connecting the unit to the appropriate Power Supply/Welding Control with the cables provided in the Ship Kit.

Unpack the Weld Head from its shipping box and verify that all components of the Ship Kit are present. The Weld Head comes from the shipping box completely assembled except for the electrodes.

NOTE: Carefully put the packing materials back in the packing boxes and store for future shipping.

Space Requirements

Allow enough space so the Operator may safely perform the welding operation and have sufficient space for the welding Control.

Power Requirements

The Weld Head 100 ➔ 240 VAC, ± 10%, 50/60 Hz, 70VA which may be available from the Power Supply/Welding Control.

In addition, the weld head requires welding current from the Power Supply/Welding Control. Refer to the Power Supply/Welding Control *Operator Manual* for power requirements of that unit.

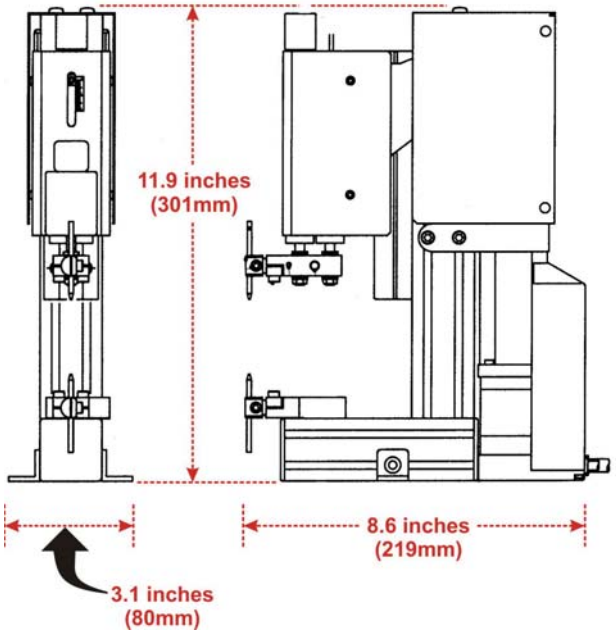
NOTE: The Weld Head is motor-driven, therefore it does ***not*** require any compressed air to operate.

Installation on a Workbench

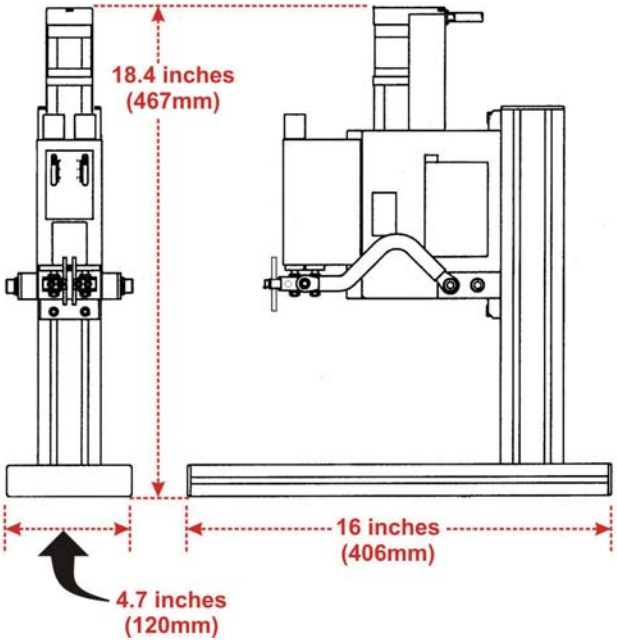
The Welding Head base has six (6) holes so that it may be installed onto a work bench. Each hole is ¼-inch (6.5mm) in diameter, with Ø.43-inch (11mm) spot facing, and is Ø.4-inches (10mm) deep.

Space Requirements

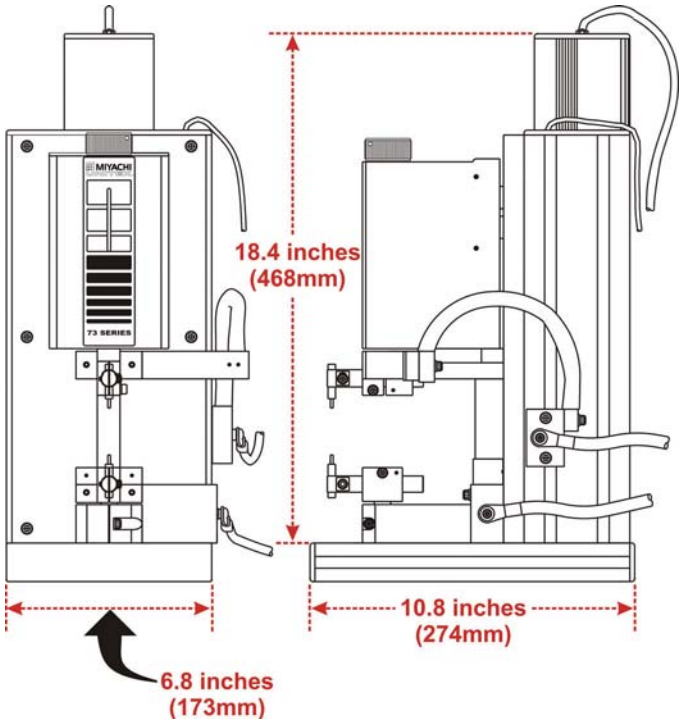
Model 71 Weld Head



Model 72 Weld Head



Model 73 Weld Head



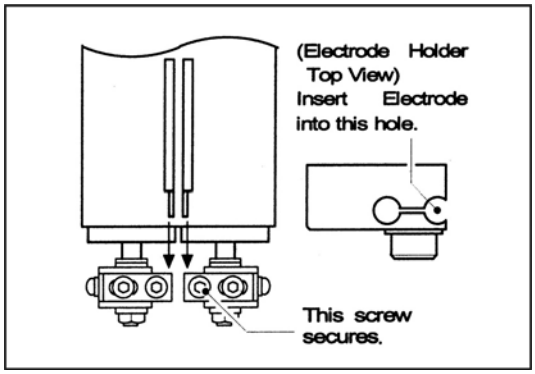
Install Electrodes

CAUTION

Do ***not*** modify the electrode holders or attach additional mechanisms to the moving parts of the head. Doing so may hurt welding performance, damage the head, and ***void the warranty***.

Installing and replacing electrodes is essentially the same for all Series 70 heads. The picture below shows the **Model 72** for reference.

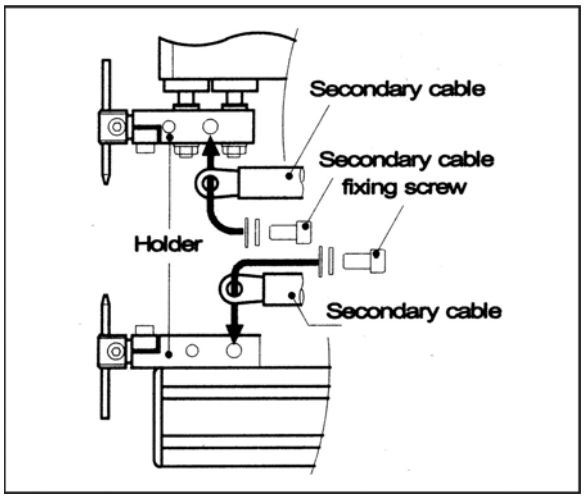
1. Loosen the Electrode Screw.
2. Insert the Electrode into the Electrode Holder.
3. Tighten the Electrode Screw to secure the Electrode in place.



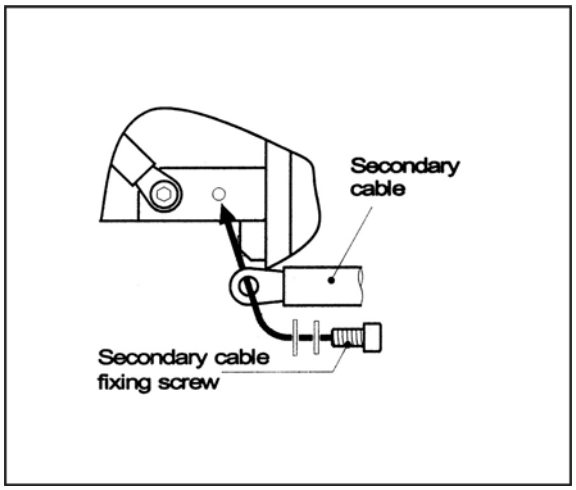
Connect Weld Cables

After installing the Weld Head on the work bench, connect the Weld Cables, also known as "secondary cables," to the head as shown below.

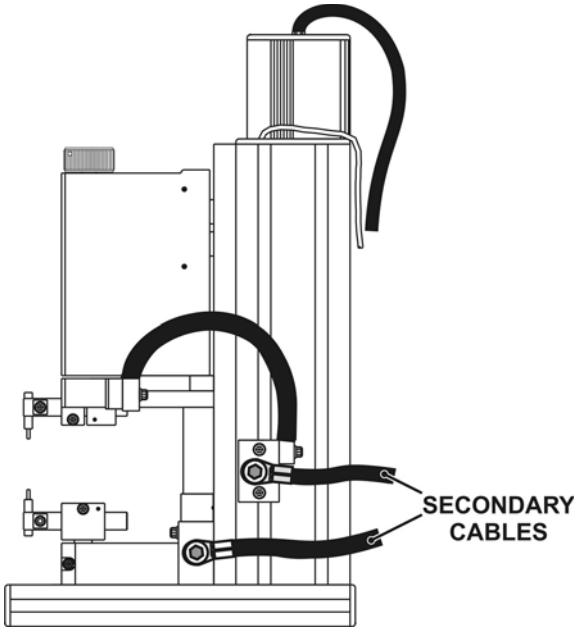
Model 71



Model 72



Model 71



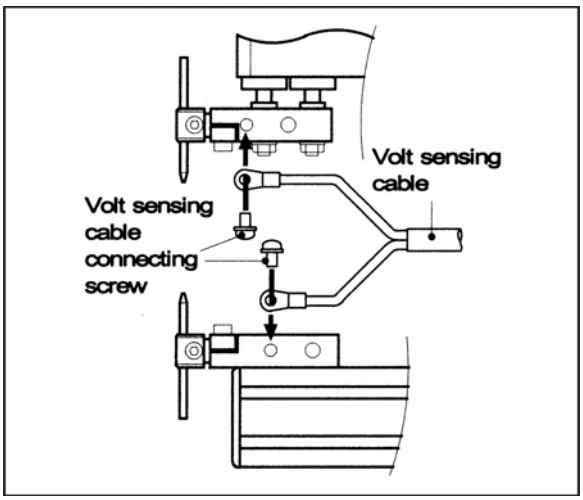
NOTES:

- These cables are ***not*** polarized.
- The connecting screws on **Model 72** are on both the left and right sides of the head.

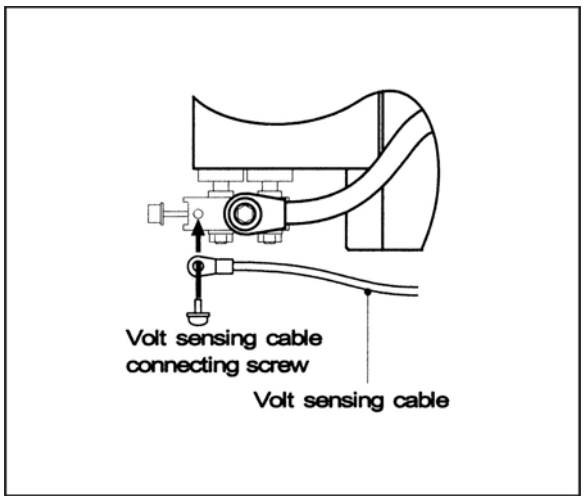
Connect Controller and Power Supply Cables

1. **Connect the Volt-Sensing Cable.** When employing the voltage-detecting function of a Power Supply, Weld Checker, etc., connect the Volt-Sensing Cables to the Electrode Holders as shown below.

Model 71 & 73



Model 72



NOTE: On the Model 72, connect the Volt-Sensing Cables on both the right and left Holders.

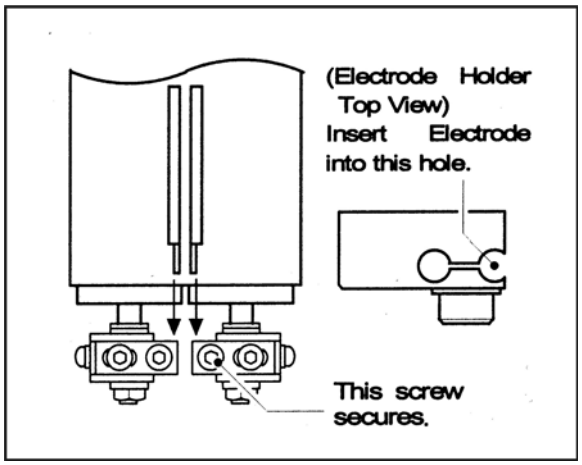
2. **Connect the Weld Force Detecting Sensor Cable**. Connect the Weld Force Detecting Sensor Cable to the Motor Controller.
3. **Connect the I/O Connector**. Connect the I/O Connector to the Motor Controller. Connect the operation switch for an emergency stop of the motor to Pins 21 and 22 of the I/O connector. Use the operation switch whose capacity is more than 24VDC, 20 mA.
4. **Connect the AC Cable**. Finally, connect the AC Cable to the 100—240VAC, 50/60 Hz outlet.

Section II: Set-up

Adjust Electrode Height

Adjust the electrode height in advance to allow LI = L2 when welding a stepped workpiece.

If the distances to the work pieces are different, two built-in photo-micro switches do ***not*** turn on simultaneously, resulting in inferior welding. This could also damage the equipment.



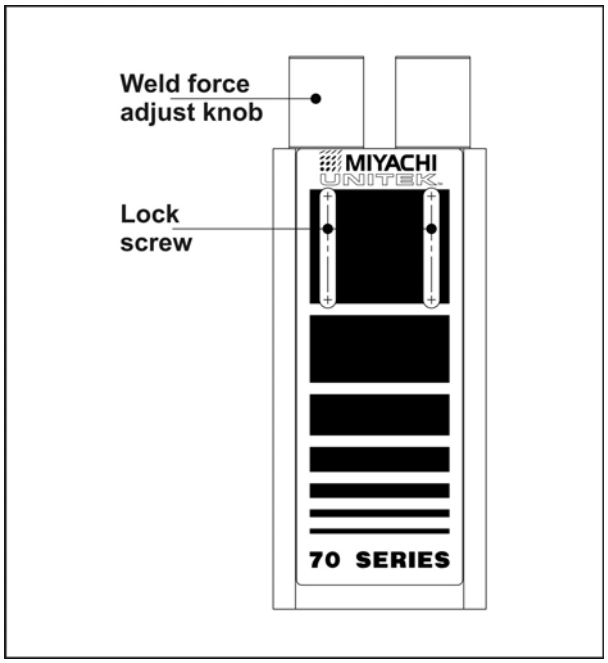
Adjust Weld Force

CAUTION

- ***Always*** stop operation ***before*** starting adjustment.
- The weld force conversion graph represents theoretical values. To measure the actual weld force, use a force gauge.

NOTE: Weld Force adjustment is the same procedure for both models. The Model 72 Weld Head is shown for reference.

1. Loosen the Lock Screw using the supplied M2.5 hex wrench.
2. The scale represents the weld force. Turn the Weld Force Adjust Knob to adjust the center of the Lock Screw to the desired weld force scale.
3. Tighten the lock screw to lock the Weld Force Adjust Knob.
4. After adjusting, measure the weld force using a pressure force gauge.

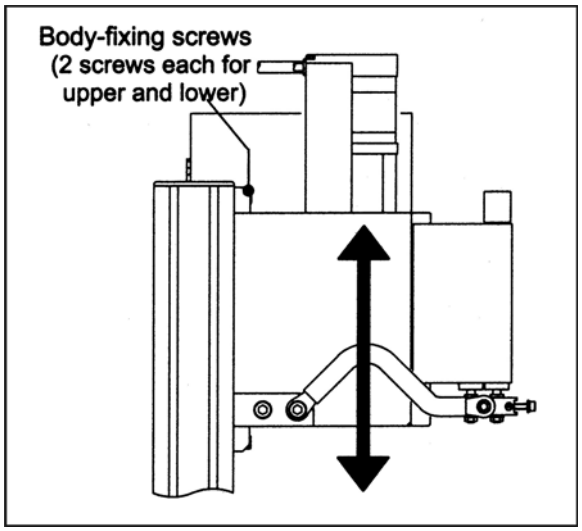


Adjust Weld Head Position

WARNING

Always support the Weld Head when you loosen the screws. If you loosen the head without support it could fall causing injury to the Operator and/or damage to the equipment.

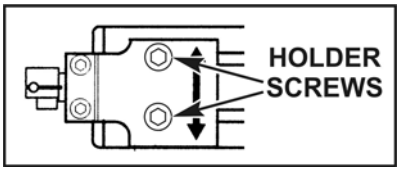
1. Unplug the AC Cable from the electrical outlet.
2. Loosen the Weld Head Screw.
3. Move the Weld Head up and down to adjust the mounting height.
4. When the head is in the desired position, tighten the Weld Head Screw firmly.

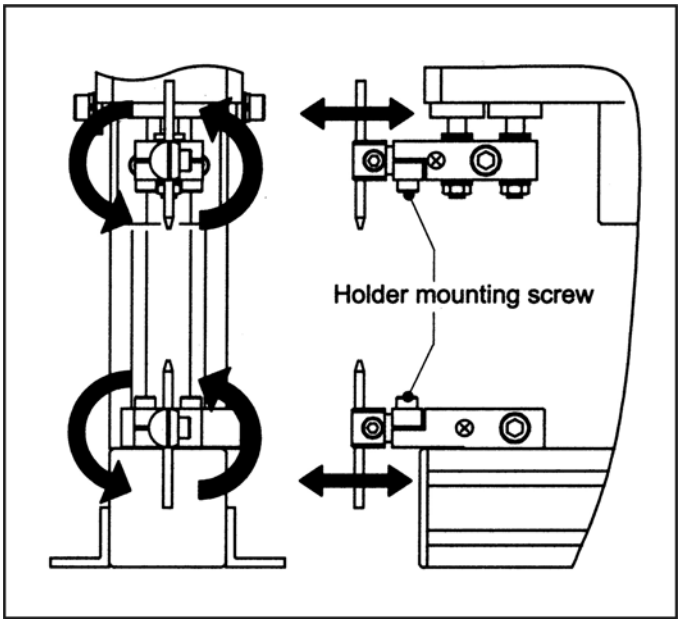


Aligning the Electrodes

1. Unplug the AC Cable from the outlet to turn off the power supply.
2. Loosen the Holder-Mounting Screws.
3. Rotate or move back and forth the Electrode Holders to align the upper and lower electrodes as shown at lower right.

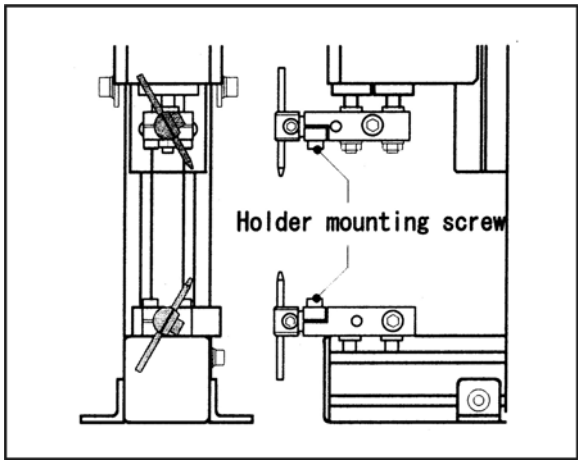
   NOTE: If you can't align the electrodes, loosen the Holder Screw to move the Electrode Holder up, down, left, or right as needed.





Adjust the Electrode Mounting Angle

1. Unplug the AC Cable from the outlet to turn off the power supply.
2. Loosen the Holder-Mounting Screws and turn the Electrode Holders to adjust the mounting angle of the electrode.
3. After the adjustment, tighten the Holder-Mounting Screw securely.



CHAPTER 3
OPERATING INSTRUCTIONS

Section I: Before You Start

Preparation

Before operating the Weld Head, read both this manual ***and*** the *Operator Manual* that came with your Power Supply/Welding control. Particularly note the specific hazards associated with those components. You ***must*** be familiar with the general principles of welding, programming weld schedules, and the operating procedures of your Power Supply/Welding Control.

Use the checklist below to make sure that all connections and settings are correct to ensure that you will achieve the highest quality welds possible.

PRE-WELD CHECKLIST	
✓	Confirm that a qualified Engineer or Technician has properly installed and setup the equipment according to the instructions in *Chapter 2, Installation and Setup.*
✓	Set the **WELD/NO WELD** Switch, located on the front of the Power Supply/Welding Control to the **NO WELD** position.
✓	Check that the weld power cables are correctly attached at both ends.
✓	Verify that the Firing Switch Cable is attached to the welding control.
✓	Verify that the Power Supply/Welding Control is connected to the appropriate power source and that the power source is turned **ON**.
✓	Verify that the Power Supply/Welding Control is turned **ON**.

Operator Safety

DANGER

- ***Always*** wear protective safety glasses when performing any welding operation.
- ***Always*** wear appropriate personal protective gear when welding.

Section II: Operation

Overview

Welding consists of:

- Adjusting the electrodes and Weld Head height to match the pieces being welded.
- Adjusting the welding force if necessary.
- Using the Controller to program the motor drive settings.
- Welding using normal shop procedures.

CAUTION

Before performing the procedures below, make sure the **WELD-/NO-WELD** switch is in the **NO-WELD** position to avoid unexpected sparking or weld current discharge that could damage equipment.

2-level Footswitch

It is of 2-level type. The first level switch is External Input 1 **STI**. The second level switch is External Input **2NDJ**. These two switches allow a variety of operations.

Electrode Position

Model 72 electrodes have five stop positions.

Position	Description
Original Point	The position where the electrode has completely returned.
Start Point	A little bit farther position from Original Point. It can be set arbitrarily. The **READY** Lamp lights up when the electrode is at this position.
Mid-Point	Just before the position where the electrode contacts workpiece. It can be set arbitrarily. MID Lamp lights up when the electrode is at this position.
Weld Point	The position where the electrode contacts workpiece. The **WELD** Lamp lights up when the electrode is at this position and causes the welding current to flow.
Downstop Point	A little bit beyond the position from Weld Point. It can be set arbitrarily.

Electrode Working Mode

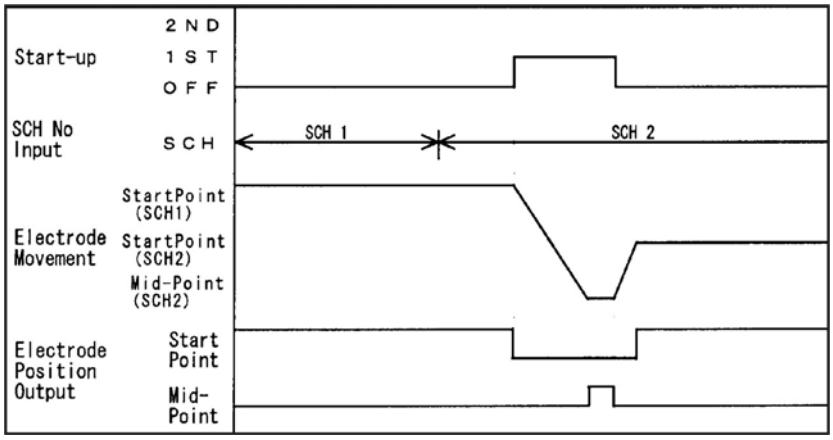
Model 72 has two working modes.

Movement	Mode 0	Mode I
For setting Position or measuring Weld Force	Performed by External Input **1ST** or **2ND**	Performed by External Input **1ST** or **2ND** or pressing the **Operation** button.
For resuming Start Point of motor	Performed by External Input **1ST** or **ORG**	Performed by External Input **1ST** or **ORG** or pressing **ORG/CANCEL** button.
Electrode is pressed on the way other than from Mid-Point to Weld Point.	Error indicated	Error indicated and the power supply to motor turned off.

In **Mode 1**, when the electrode is at **Start Point** and no setting is performed, then **A** is shown on **SPEED HOLD TIME Display**.

Change of Schedule Number

Changing the **Schedule No.** does not cause the electrode to move. The electrode's **START POINT** stays at the position of the previous schedule. In case that Start Point of the new **Schedule No**. differs from the one of the last **Schedule No**., move the electrode to the Mid-Point and back to get the new Start Point.



- In case of continuous operations across several Schedule Numbers, set each Start Point the same.
- When the weld force is exerted on the electrode on the way other than moving from Mid-Point to Weld Point, then the fault code "E" is displayed.

In Case of Mode 0

When a problem occurs between Mid-Point and Start Point, open External Input **1ST** to make the electrode move to Start Point.

When a problem occurs between Start Point and Original Point, open External Input **1ST** to make the electrode move to Original Point. At the Original Point, External Output **START POINT** is output.

In case of Mode 1

Power to the motor is turned OFF to stop.

Mode Setting

Setting

1. Turn on the power while pushing the Operation button. The character of **Set** blinks on the **SCH** (Schedule) display and **SPEED HOLD TIME** Display.
2. Continue to press the button until blinking changes stays on.
3. Depress the Operation button, and "0" blinks on **SPEED HOLD TIME** Display. Rotate the Operation button to choose one of the following settings.
   - **0** means "Change of **Mode**."
   - **1** means "Change of **ERROR** signal output."
   - **E** means "**End**."

Changing Mode

1. Press the Operation button while **0** blinks on **SPEED HOLD TIME** Display.
2. **Mode No.** blinks on **SCH** (Schedule) display. Rotate the **Operation** button to select "**0**" or "**1**."
3. Press the **Operation** button to set the **Mode No**.
4. Finally, be sure to perform the **End of Setting** operation below.

Change of ERROR Signal Output

5. Press the **Operation** button while **1** blinks on **SPEED HOLD TIME** Display.
6. **Mode No.** blinks on **SCH** (SCHEDULE) Display. Rotate the **Operation** button to select **0** or **1**.
   - **Q** means circuit opened in case of error"
   - **1** means "circuit closed in case of error"
7. Press the **Operation** button to set the **ERROR** signal output.
8. Finally, be sure to perform the End of Setting operation below.

End of Setting

9. Rotate the **Operation** button to select "**E**". Press the **Operation** button to fix.
10. Confirm **End** on **SCH** (SCHEDULE) and **SPEED HOLD TIME** Display, which means the completion of setting.
11. Turn the power OFF.

Applying Power and Moving to Start Point

1. Turn the power ON.
2. Zero **0** blinks on **SCH** Display of the front panel.
3. Close the circuit of **External Input** (**1ST** or **ORG)**, and the electrode, after it once returns back to **Original Point**, moves to **Start Point**.
4. If the circuit of **External Input** is opened while electrode is moving, the electrode stops there.
5. When the circuit of **External Input** is closed again, the electrode begins to move.
6. When the electrode reaches **Start Point**, the **READY** lamp lights up and the preparation is completed.

   NOTES:

   - The Original Point and Start Point are at the same position when the shipping package is opened and the power is supplied for the first time.
   - In case of **Mode 1**, it works by pressing **ORG/CANCEL** button in addition to **1** the use of External Input.

Auto-Set the Electrode Position

1. The electrode position can be set automatically by means of the auto-setting function. Turn the **Operation** button to light up the **AUTO** Lamp.
2. Press the **Operation** button for 1 second, and the **AUTO** lamp will blink.
3. Close the External Input (**1ST**), and the electrode moves to Original Point.
4. Open External Input when electrode stops and the Controller beeps.

   NOTE: The Controller beeps when the package is opened and the power is supplied for the first time, because Original Point and Start Point are at the same position.
5. A numeral blinks on **SCH** Display. Turn the **Operation** button to change **Schedule No**.
6. When **Schedule No.** is determined, press the **Operation** button.
7. The blinking numeral on **SCH** Display changes to the illuminated one.
8. Position the workpiece to be welded.
9. Close External Input **1ST** and **2ND** to make the electrode move forward. Hold the External Input **1ST** and **2ND** closed. The electrode presses the workpiece and the Controller beeps.
10. When the application of the electrode force is completed, the electrode returns to the position before Original Point and the Controller beeps.
11. Open External Input **1ST** and **2ND** to complete the auto-setting with a beep. The position where the electrode stops is Start Point.

12. The electrode positions determined by the auto-setting are as follows:

Electrode Position	Description
Original Point	Position where the electrode has completely returned.
Start Point	Between Weld Point and Original Point.
Mid-Point	2mm before Weld Point.
Downstop Point	5mm beyond Weld Point.

NOTE: The electrode speed and **Hold Time** are ***not*** set automatically. The previous settings are valid. Change these settings manually.

In case of **Mode 1**, it works by pressing the **Operation** button in addition to the use of External Input. When using the **Operation** button, press the **Operation** button again, because the electrode stops after pressing the workpiece.

Manually Set the Electrode Position

Selecting Schedule No.

1. Turn the **Operation** button to light up **SCH** lamp.
2. Press the **Operation** button for I second. **SCH** Lamp and **SCH** Display blink.
3. Turn the **Operation** button clockwise and counterclockwise to select a numeral (**1** to **31**) on the **SCH** Display.
4. After selecting **Schedule No.**, press the **Operation** button.
5. Press **ORG/CANCEL** button to interrupt the operation.
6. Setting Start Point
7. Turn the **Operation** button to light up **READY** Lamp.
8. Press the **Operation** button for 1 second, and **READY** Lamp lights up.
9. Close the **External Input** (**1ST**).
10. The electrode moves to Start Point with and the Controller beeps. (When the electrode has been at Start Point, only beeps are given. No motion is observed)
11. Open the External Input (**1ST**).
12. Turn the **Operation** button clockwise and counterclockwise to make the electrode move forward and backward in 0.1 mm-increment/decrement.
13. Press the **Operation** button until the electrode reaches the desired position. The **READY** lamp will blink fast.
14. Close the External Input (**1ST**). The Start Point setting is completed and the Controller beeps.

NOTE: When you want to interrupt the operation, press the **ORG/CANCEL** button, and the **READY** lamp blinks fast.

15. Close the External Input (**1ST**). The electrode returns to the previous position with beeps. In case of **Mode 1**, it works by pressing the **Operation** button in addition to the External Input (**1ST**).

Changing Moving Speed between Start Point and Mid-Point

1. Turn the operation button to light up both **READY** and **MID** Lamp.
2. Press the **Operation** button for 1 second. The **READY** and **MID** lamps will blink.
3. The number of blinking **SPEED HOLD TIME** Lamp indicates the current speed setting. Turn the **Operation** button clockwise and counterclockwise to change the number of the blinking lamp. Select your desired speed.

Number	Moving Speed (mm/s)	Note
1	20	Minimum
2	60	
3	100	
4	140	
5	180	
6	220	
7	260	
8	300	Maximum

4. After setting the speed, close and thereafter open External Input **1ST**. Check the speed of the electrode that moves forward and backward.
5. Press the **Operation** button when your desired speed is determined.

NOTE: Press **ORG/CANCEL** button to interrupt.

Setting Mid-Point

1. Turn the **Operation** button to light up **MID** Lamp.
2. Press the **Operation** button for I second. **MID** Lamp blinks.
3. Close External Input **1ST** to make the electrode move to Mid-Point with beeps.
4. Open the External Input **1ST**.
5. Turn the **Operation** button clockwise and counterclockwise to make the electrode move forward and backward in 0.1 mm-increment/decrement.
6. Press the **Operation** button when the electrode reaches the desired position and the **MID** Lamp will blink quickly.

7. Close External Input **1ST**. The electrode moves to Start Point with beeps to complete Mid-Point setting.
8. When you want to interrupt the operation, press the **ORG/CANCEL** button, and the **MID** Lamp blinks fast.
9. Close External Input **1ST**. The electrode returns to the previous position with beeps.
10. In case of **Mode 1**, it works by pressing the **Operation** button in addition to External Input.

Setting Moving Speed from Mid-Point to Weld Point

1. Turn the **Operation** button to light up all of the **MID**, **WELD** and **FORCE CHK** Lamps.
2. Press the **Operation** button for I second. The **MID**, **WELD** and **FORCE CHK** Lamps blink.
3. The number of the blinking **SPEED HOLD TIME** Lamp indicates the current speed setting. Turn the **Operation** button clockwise and counterclockwise to change the number of the blinking lamp. Select your desired speed.

Number	Moving Speed (mm/s)	Note
1	7.5	Minimum
2	15	
3	25	
4	30	Maximum

4. After setting the speed, close and thereafter open External Input both **1ST** and **2ND**. Check the speed of the electrode that moves forward and backward.
5. Press the **Operation** button when your desired speed is determined. Press the **ORG/CANCEL** button to interrupt.

Setting Downstop Point

1. Turn the **Operation** button to light up **WELD** Lamp.
2. Press the **Operation** button for 1 second. The **WELD** Lamp will blink.
3. Close External Input **2ND** to make the electrode move to Downstop Point with beeps.
4. Open External Input **2ND** and **1ST**.
5. Turn the **Operation** button clockwise and counterclockwise to make the electrode move forward and backward in 0.1 mm-increment/decrement.
6. Press the **Operation** button when the electrode reaches the desired position. The **WELD** Lamp will blink quickly.

In Case the Electrode Cannot Move Beyond the Weld Point Because of a Workpiece

1. Turn the **Operation** button until the electrode stops, then press the **Operation** button again.
2. Downstop Point is set 5mm beyond Weld Point and the **WELD** Lamp blinks fast.
3. Close External Input **1ST**. The electrode moves to Start Point with beeps to complete Weld Point setting.

When you want to interrupt the operation

1. Press **ORG/CANCEL** button, and the **WELD** Lamp blinks fast.
2. Close External Input **1ST**. The electrode returns to the previous position with beeps.
3. In case of **Mode 1**, it works by pressing the operation button in addition to External Input.

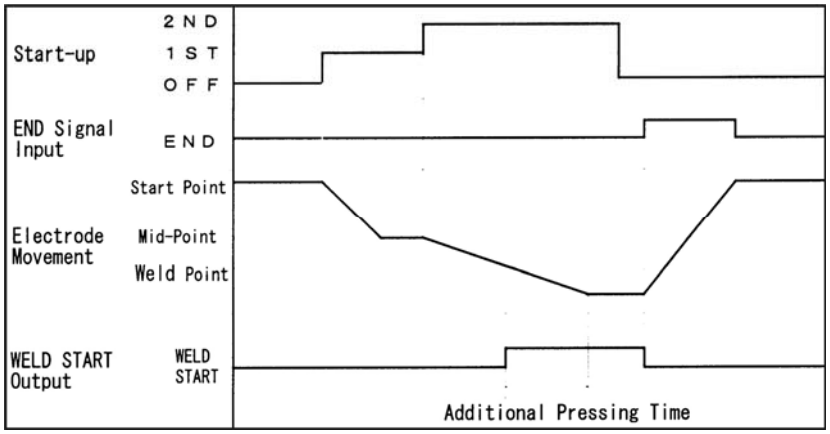
Setting Additional Squeeze time at Weld Point

1. By the function of setting the additional squeeze time, the additional electrode force can be exerted on the electrode for desired period without stopping the motor.
2. Turn the **Operation** button to light up both **WELD** and **HOLD** Lamp.
3. Press the **Operation** button for 1 second and the **WELD** and the **HOLD** Lamps will blink.
4. The number of the blinking **SPEED HOLD TIME** Lamp indicates the additional squeeze time setting. Turn the **Operation** button clockwise and counterclockwise to change the number of the blinking lamp. Select your desired period.

SPEED HOLD TIME Lamp Number	Additional Squeeze time (ms)	Note
0	0	Stop at Weld Point
1	10	Minimum
2	20	
3	30	
4	40	
5	50	
6	60	
7	70	
8	80	
9	90	

4. Press the **Operation** button when your desired period is indicated.

   NOTE: Press the **ORG/CANCEL** button to interrupt.



Setting Hold Time

1. Turn the **Operation** button to light up **HOLD** Lamp.
2. Press the **Operation** button for1 second and the **HOLD** Lamp will blink.
3. The number of the blinking **SPEED HOLD TIME** Lamp indicates the present Hold Time setting. Turn the **Operation** button clockwise and counterclockwise to change the number of the blinking lamp. Select your desired speed.

Number	Hold Time (ms)	Note
1	100	Minimum
2	200	
3	300	
4	400	
5	500	
6	1000	
7	2000	
8	Waits for input.	

4. After selecting the number, close and thereafter open External Input both **1ST** and **2ND**. Check the Hold Time, observing the electrode that moves up and down.
5. Press the **Operation** button when your desired Hold Time is determined.

   NOTE: Press **ORG/CANCEL** button to interrupt.

Setting Moving Speed from Weld Point to Mid-Point

1. Turn the **Operation** button to light up both **MID** and **WELD** Lamp.
2. Press the **Operation** button for 1 second. The **MID** and **WELD** Lamps will blink.
3. The number of the blinking **SPEED HOLD TIME** Lamp indicates the current speed setting.
4. Turn the **Operation** button clockwise and counterclockwise to change the number of the blinking lamp. Select your desired speed.

Number	Moving Speed (mm/s)	Note
1	20	Minimum
2	60	
3	100	
4	140	
5	180	
6	220	
7	260	
8	300	Maximum

Section III. Welding

Operation

1. Close External Input **2ND**. Then the electrode moves forward to Weld Point.
   - When the electrode contacts the workpiece and the weld force reaches the setting value, then the electrode stops. Weld Start Signal is output and the welding starts.
   - When Weld Start Signal is once output, the weld force of the electrode is maintained although the footswitch is released.
   - When Hold Time has elapsed or End Signal is output from the welding power supply, the weld force is released.

   NOTE: In case that End Signal ***cannot*** be input although Hold Time is set to "**8**," press **ORG/CANCEL** button while pressing the footswitch. The electrode returns to Start Point or Mid-Point.
2. After the weld force of the electrode is released, open External Input both **1ST** and **2ND**. Then, the electrode returns to Start Point. In case that External Input **1ST** is closed, the electrode returns to and stops at the Mid-Point.

   NOTE: When External Input **2ND** is closed while the electrode is at Mid-Point, the electrode starts to apply the weld force again. Be sure ***not*** to release the electrode while welding current is being applied.

Measuring Weld Force

1. Turn the **Operation** button to light up **FORCE CHK** Lamp.
2. Press the **Operation** button for 1 second. The **FORCE CHK** Lamp blinks and a numeral blinks on **SCH** Display. A minus lights up on **SPEED HOLD TIME** Display on the Model 72; a vertical bar "1" on the Model 72.
3. Rotate the **Operation** button to change **Schedule No**. The **FORCE CHK** Lamp blinks. A minus "**—**" blinks on **SPEED HOLD TIME** Display on the Model 72; a vertical bar on the Model 72. On the Model 72, you can select one from the right and left electrodes to measure. The blinking "**I**" indicates the electrode to be measured.
4. Rotate the **Operation** button to move "**I**" to the right or left.
5. Set up a force gauge.
6. Close the External Input **2ND**. The electrode moves forward. When the electrode contacts the force gauge, the electrode stops with beeps.
7. Open External Input **2ND**, and measure the weld force.
8. Close External Input **1ST**. The electrode returns to Start Point.
9. After the electrode has returned to Start Point, press **ORG/CANCEL** button to complete the mode of measuring the weld force. In case of **Mode 1**, it works by pressing the operation button in addition to External Input.

   NOTE: When you want to interrupt the operation, ***except at the Start Point*****,** press the **ORG/CANCEL** button. The **FORCE CHK** Lamp will blink fast. Close the External Output **1ST**. The electrode returns to Start Point and the Controller beeps.

CHAPTER 4
MAINTENANCE

Section I. Troubleshooting

When a problem occurs, the **TROUBLE** Lamp lights up and a fault message is shown on the **SCH** Display. Closing the External Input **RESET** or continuing to press the operation button can reset the fault signal.

Message	Fault	Corrective Action
E (Mode 0)	Electrode force is applied on the way to return to Start Point	Close External Input **1ST** again to make the electrode move to Original Point. Rectify the cause of the problem. Thereafter, reset the fault signal and close External Input **1ST**. The **TROUBLE** output is released.
	Electrode force is applied before Mid-Point	Close External Input **1ST** and **2ND** to make the electrode return to Start Point. Rectify the cause of a trouble. Thereafter, reset the fault signal and close External Input **1ST**. The **TROUBLE** output is released.
E (Mode 1)	Electrode force is applied on the way to return to Start Point or applied before Mid-Point	After rectifying the cause of a trouble, reset the fault signal and resume Start Point.
1	Fault occurred in controller memory	Some settings have been lost. You must re-set again. Turn on the power while pressing **ORG/CANCEL** button to clear all the settings.
2	Fault occurred in memory's R/W-function in controller	Turn off the power and thereafter, turn it on again. If the problem continues, contact Miyachi Unitek for repair.
3	Fault occurred in controller CPU	After turning off the power or resetting the fault signal, resume Start Point. If the problem continues, contact Miyachi Unitek for repair.
4	Fault occurred in electrode-driving motor	After turning off the power or resetting the fault signal, resume Start Point. If the problem continues, contact Miyachi Unitek for repair.
5	Fault occurred in the control signal of electrode-driving motor	After turning off the power, check the connector conduction between the controller and motor. If the problem continues, contact Miyachi Unitek for repair.
6	STOP-Pin circuit is opened	Close the circuit of **STOP-Pin**. After turning off the power or resetting the fault signal, resume Start Point.

Section II. Maintenance

Service

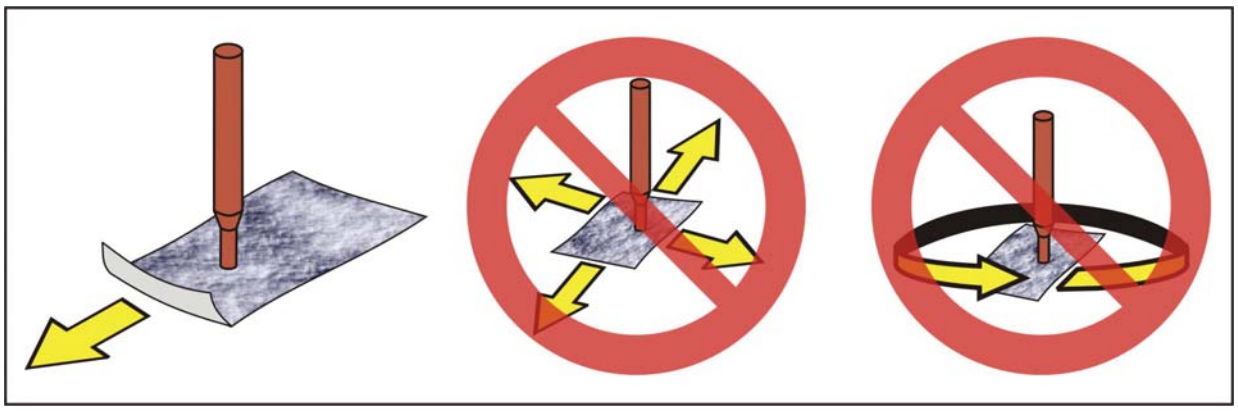
There are ***no*** User-serviceable parts in the Weld Head or Controller. If they need service, or if you have problems you cannot resolve, contact us at the address, e-mail, or phone number listed in **CONTACT US** in the front of this book. The ***only*** maintenance the User can perform is to routinely clean and replace the electrodes.

Electrode Cleaning

Clean the electrode tips periodically to remove oxides and welding debris.

1. Use 600 grit sandpaper or finer to clean the electrodes.
2. Place the sandpaper beneath electrodes. The electrodes should contact with paper with a force low enough to allow the paper to be moved without damaging the electrodes.
3. Gently pull the sandpaper forward one or two inches ***in a straight line only***.

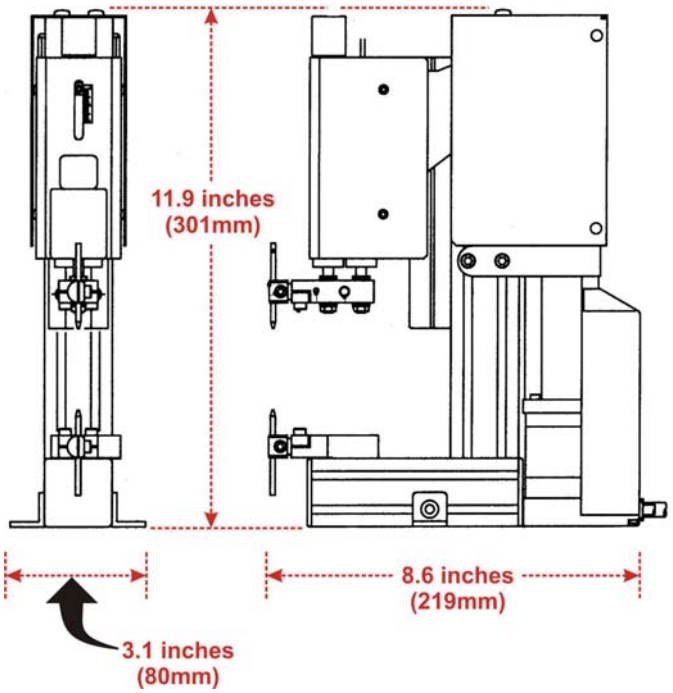
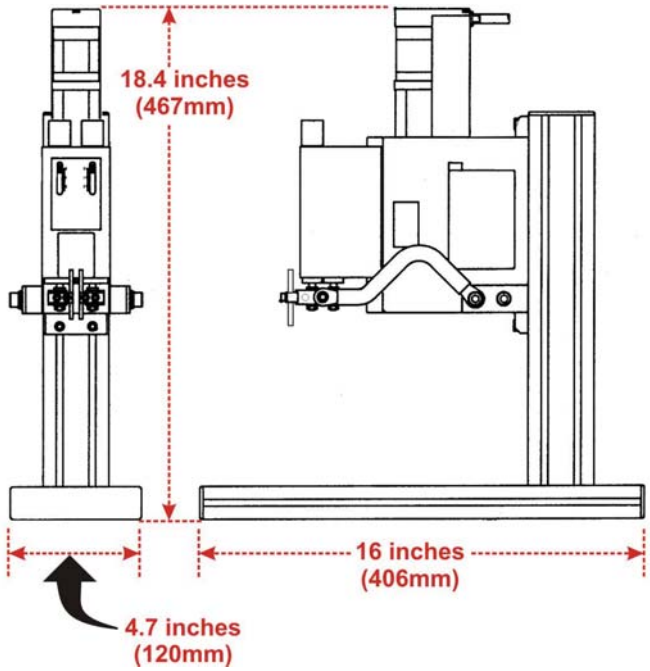
   CAUTION: Do ***not*** move the paper from side-to-side or in a circular motion or you may damage the electrodes.



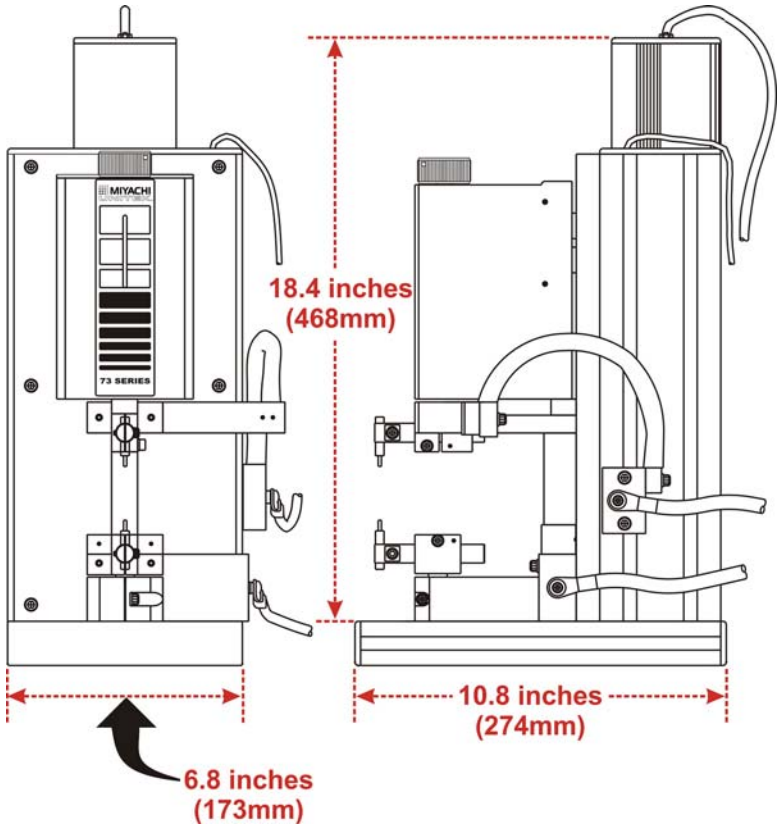
4. Clean the electrode face with a small cotton swab saturated in alcohol.

APPENDIX A
TECHNICAL SPECIFICATIONS

Specifications

Item	Description
MODEL 71 **Dimensions**	
MODEL 72 **Dimensions**	

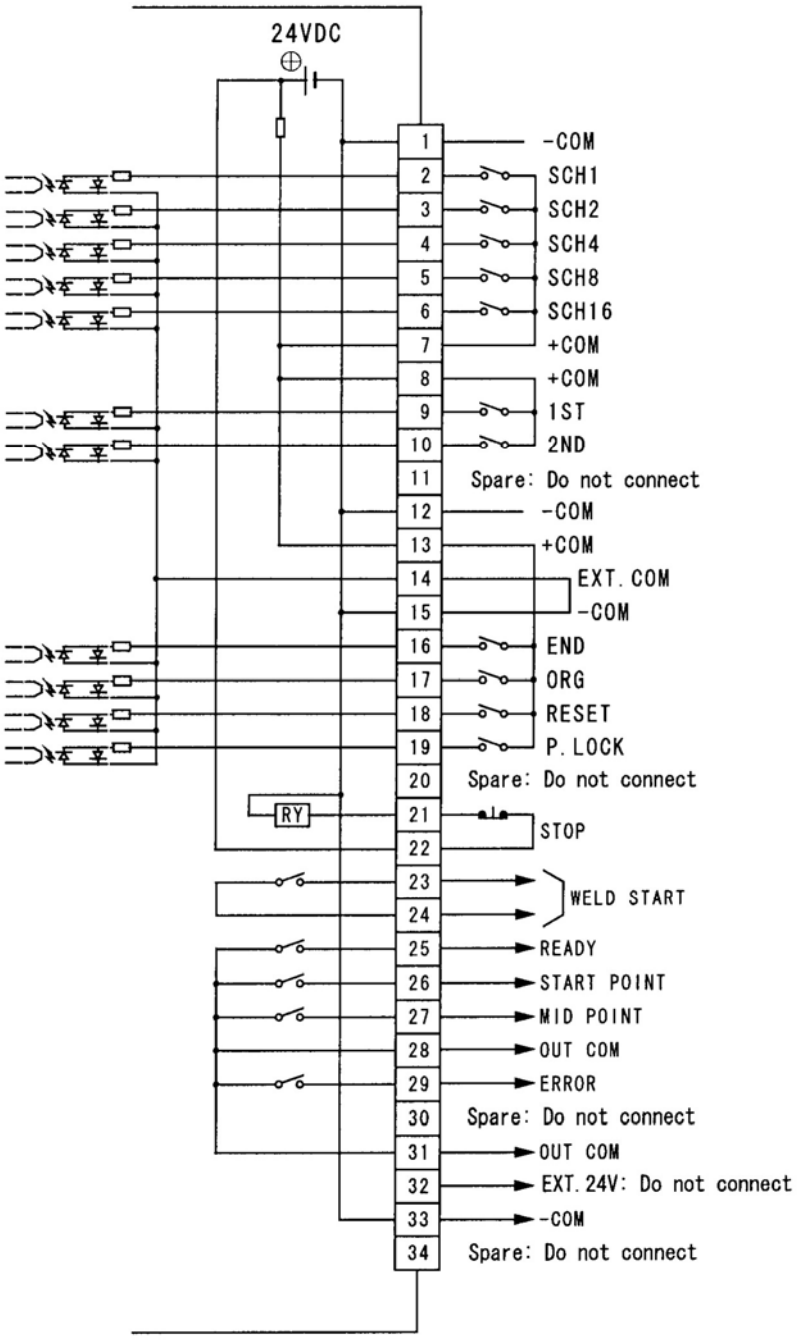
APPENDIX A: SPECIFICATIONS

Item	Description		
MODEL 73 Dimensions			
Head Type	**Model 71**	**Model 72**	**Model 73**
	For Opposed Welding	For Series Welding	For Series Welding
Electrode Force	1 – 8 lbs. (0.45 – 3.6 kgf)	1 – 8 lbs. (0.45 – 3.6 kgf) per electrode	15-110 – 8 lbs. (0.45 – 3.6 kgf) per electrode
Weld Force Method	Spring-Forced	Spring-Forced	Spring-Forced
Electrodes	ES0400 Series (0.125 inch diameter)	Unibond Electrodes	ES0400 Series (0.125 inch diameter)
Weight	Head: 15 lbs (6.8 kg) (Including Baseplate) Controller: 4.6 lbs (2.1 kg)	Head: 17 lbs (7.7 kg) (Including Baseplate) Controller: 4.6 lbs (2.1 kg)	Head: 35.2 lbs (16 kg) (Including Baseplate) Controller: 4.6 lbs (2.1 kg)
Throat Depth	8.5 inches (216 mm)	8.5 inches (216 mm)	5.25 inches (133.3 mm)
Maximum Current Rating	3,000 A (At 2% Duty Cycle)	3,000 A (at 2% duty cycle)	7,500 A (at 2% duty cycle)
Electrode Speed	8 Speeds between Start Point ➔ Mid-Point and Weld Point ➔ Mid-Point. 4 Speeds between Mid-Point ➔ Weld Point. (All speeds are selectable for each Schedule)		
Electrode Drive Method	Servo Motor		

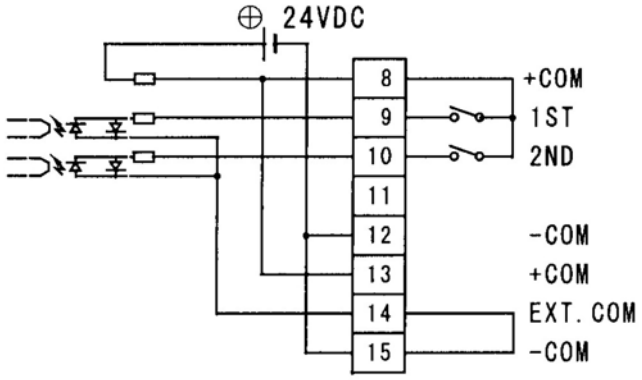
Item	Description
Electrode Stroke	1.7 inches (43 mm) Maximum
Hold Time Setting	7 Settings
Number of Weld Schedules	31 Schedules (Externally Selectable)
Operating conditions	Temperature: 0° ➔ 40°C, Humidity: 90% or less (No condensation)
Power Supply Voltage	100 ➔ 240 VAC, ± 10%, 50/60 Hz, 70VA

APPENDIX B
ELECTRICAL AND DATA CONNECTIONS

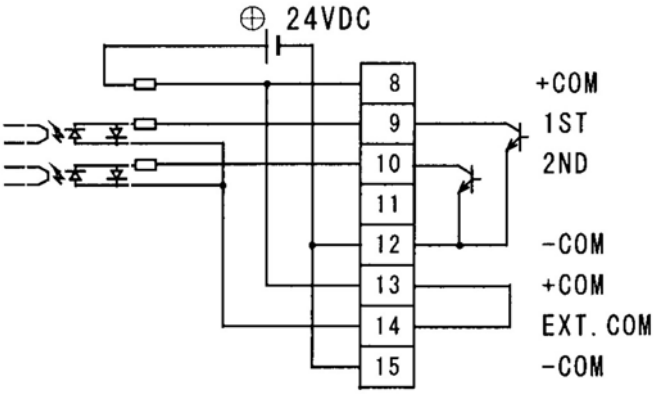
External Input/Output Signal Connections



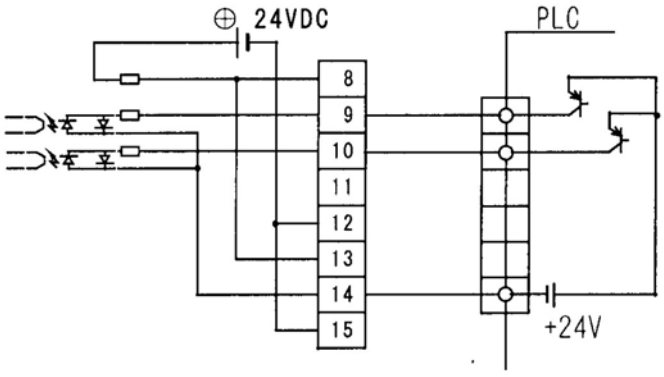
EXAMPLE: When contacts are used as the Input Terminal of the I/O Connector.



EXAMPLE: When an NPN transistor (sink type) on a PLC is used as the input terminal of the I/O Connector.



EXAMPLE: When a PNP transistor (source type) on a PLC is used as the input terminal of the I/O Connector.



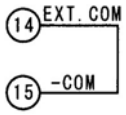
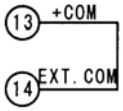
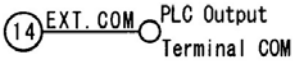
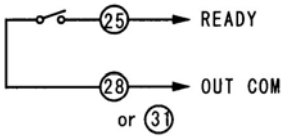
I/O Connector

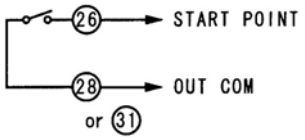
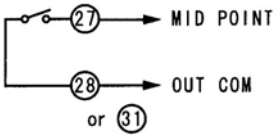
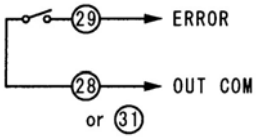
Pin #	I/O	Description
1	Input	Internally connected to GND (ØV).
2		Select a schedule number, referred to as **SCH No.** below, indicating a combination of the circuit-closed pins among Pins, No. 2, 3, 4, 5 and 6 (See table below.). The schedule number selected by I/O Connector has priority over the schedule number set on the Controller. Before selecting the schedule number by the **Operation** button on the Controller, open the circuits of all the Pins of No. 2, 3, 4, 5 and 6 in I/O Connector. Input **SCH** signal at least 2 ms before the welding current flows. During in operation, the schedule number cannot be changed.
3		
4		
5		
6		

Pin No. / SCH No.	6	5	4	3	2
1					●
2				●	
3				●	●
4			●		
5			●		●
6			●	●	
7			●	●	●
8		●			
9		●			●
10		●		●	
11		●		●	●
12		●	●		
13		●	●		●
14		●	●	●	
15		●	●	●	●
16	●				

Pin No. / SCH No.	6	5	4	3	2
17	●				●
18	●			●	
19	●			●	●
20	●		●		
21	●		●		●
22	●		●	●	
23	●		●	●	●
24	●	●			
25	●	●			●
26	●	●		●	
27	●	●		●	●
28	●	●	●		
29	●	●	●		●
30	●	●	●	●	
31	●	●	●	●	●

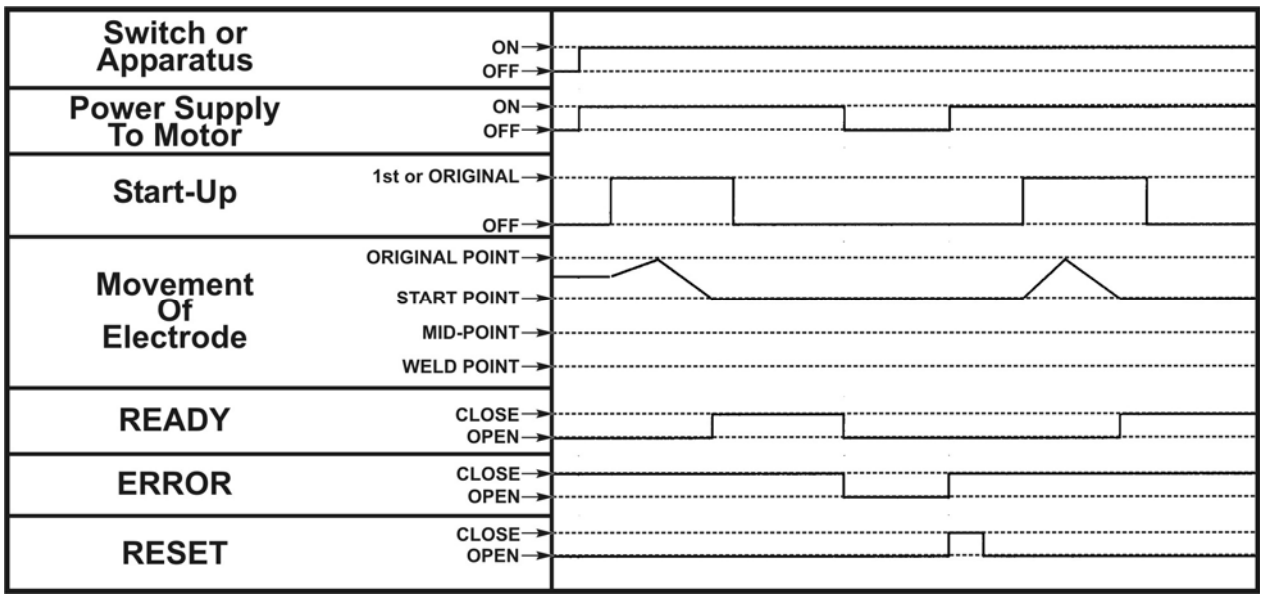
7		Output pins for 24 VDC through 100Ω internal resistor.
8		
9		Input pin for start-up signal. When 1st is closed, electrode moves from **Start Point** to **Mid-Point**. When 2nd is closed after 1st was closed, electrode moves from **Mid-Point** to **Weld Point**. Although only 2nd is closed, electrode does not move.
10		
11		Spare pin: Do ***not*** connect.
12		Factory-connected to **GND** (ØV).
13		Output pins for 24 VDC through 100Ω internal resistor.

Pin #	I/O	Description
14		According to the usage, connect pins as follows. ● When a contact is used as the input signal of the I/O Connector, connect pins 14 and 15.  ● When an NPN transistor (sink type) on a PLC is used as the input signal of the I/O Connector, connect Pins 13 and 14. The **COM** terminal of a PLC connects to **COM** Pins 1, 12, and 15.  ● When a PNP transistor (source type) on a PLC is used as the input signal of the I/O Connector, connect Pins 14 to the **COM** terminal of the PLC. 
15		Factory-connected to **GND** (ØV).
16		Input pin for the **END** signal from welding power supply. If Pin 16 is closed, the input signal of 2nd cannot be accepted.
17	Input	Input pin for Start Point resuming signal. When the circuit of Pin 17 becomes closed, the electrode resumes **Start Point**. (In case that the motor finishes moving back to **Original Point**, the electrode does not move.)
18		Input pin for **RESET** signal. If a trouble occurs, rectify the trouble and close the circuit of the Pin to turnoff **NG** signal. (See Chapter 7 for fault codes.) Close at least for 2 ms. Pin 18 does not work while the circuit of Pin 18 is closed.
19		Input pin for prohibiting changing the program When Pin 19 is closed, the program of **MH-P2OA/D2OA** cannot be modified.
20		Spare pin: Do ***not*** connect.
21	Output	Output pin for an emergency stop of the motor. When the circuit between Pins 21 and 22 is opened, the motor carries out emergency stop. Connect the operation switch for an emergency stop of the motor to Pins 21 and 22 of the I/O connector. Use the operation switch whose capacity is more than 24VDC, 20 mA.
22		
23		Output pin for current-supplying start signal to the welding power supply. When the weld force is completed, the circuit between Pins 23 and 24 becomes closed. Contact capacity is 24 VDC, 20 mA.
24		
25		Output pin for completion signal of being ready for work. When the resumption of **Start Point** is Output completed, the Pin becomes closed. If the Controller has an emergency, the Pin becomes opened. 

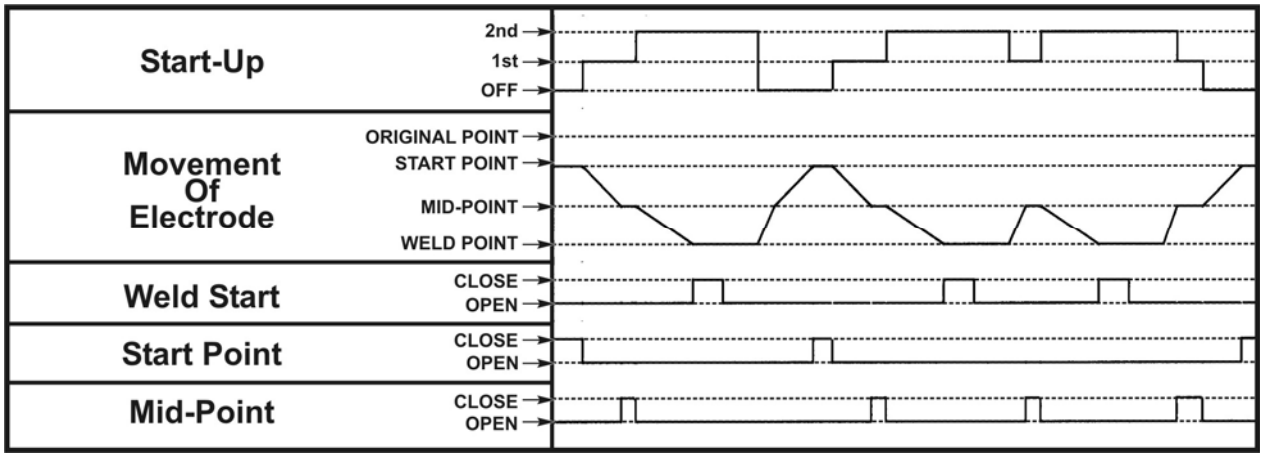
26		Output pin for completion signal of arriving at **Start Point**. When the electrode is at Start Point, the Pin becomes closed.	
27		Output pin for completion **MID POINT** signal arriving at the Mid-Point. When the electrode is at **Mid-Point**, the **COM** Pin becomes closed.	
28		Common terminal to **READY**, **START POINT**, **MID POINT** and **ERROR**.	
29		Output pin for a trouble signal. When trouble occurs in **MH-P2OAJD2OA,** the Pin becomes opened until it is reset.	
30		Spare pin: Do ***not*** connect.	
31		Common terminal to **READY**, **START POINT**, **MID POINT** and **ERROR**.	
32		Do ***not*** connect to the Pin for **EXT. 24 V**.	
33		Connected to **GND** (ØV) internally at factory shipment.	
34		Spare pin: Do ***not*** connect.	

APPENDIX C
TIMING

Power ON and ERROR Indication



Operation



APPENDIX D
COMMUNICATIONS

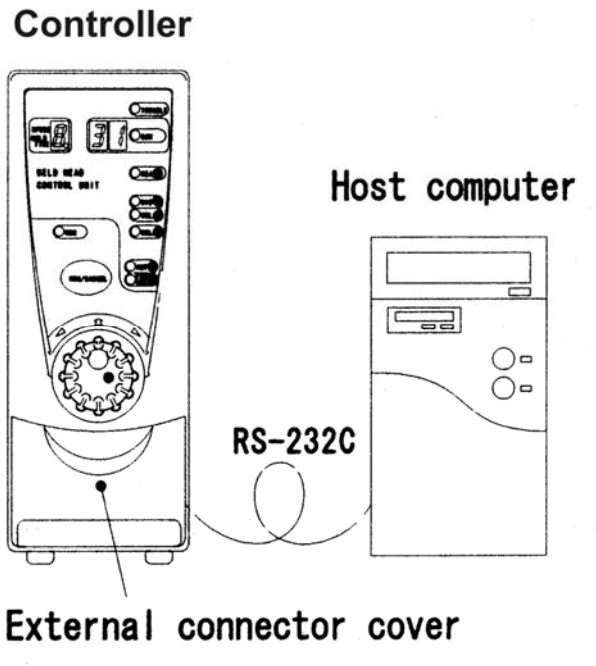
Specifications

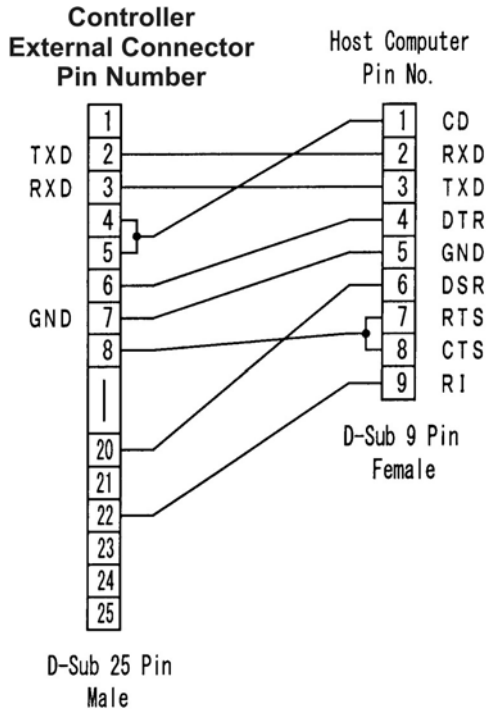
Method	RS-232C: RS-232C, Asynchronous, Teletype procedure RS-485: RS-485, Asynchronous, Half-duplex
Transmission Rate	9600 bps
Data Type	Start bit: ------- 1 Data bit: ------- 8 Stop bit: ------- 1 Parity bit: ------- 1 (Even parity)
Character Code	ASCII (CR code is indicated as " $^{C}_{R}$ " and LF code as " $^{L}_{F}$ ")

Connections

RS-232C

RS-232C signals use **TXD**, **RXD**, and **GND**. The communication connector is inside the external connector cover.

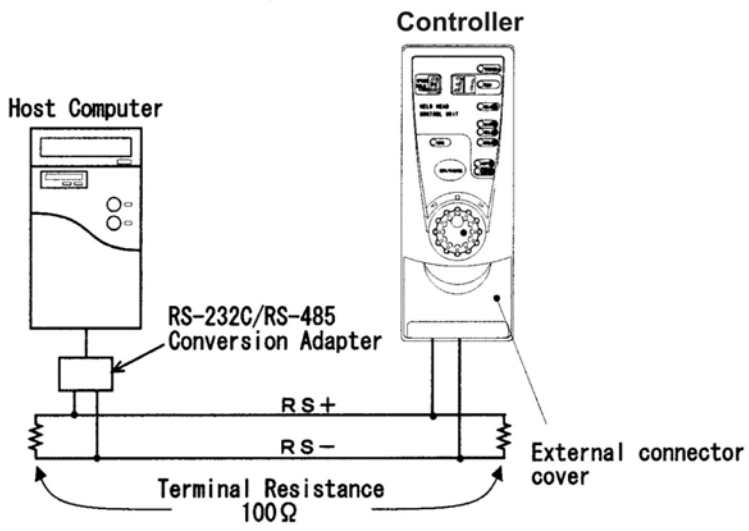


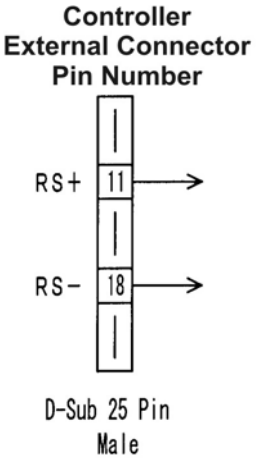


NOTE: **DTR** and **DSR** are ***not*** used with the **Controller**. **CTS** is ***not*** checked at the beginning of communication.

RS-485

RS-485 signals use **RS+** and **RS-**. The communication connector is inside the external connector cover.





NOTES:

- RS-485 operation requires a user-provided RS-232C-to-RS-485 converter/adapter.
- Mount a 100Ω terminal resistor at both ends of the RS-485 cable as shown above.

Bidirectional Communication

The **Schedule** data can be read and written by the command on the host computer side. When the electrode is at **Start Point**, the schedule data can be read or written.

When the readout/overwrite command is sent from the host computer, **MH-P2OA/D2OA** sends back the data. When sending the command, do ***not*** send the next command until the data are sent back or the timeout time elapses.

When using the overwrite command, compare the **Schedule** of the overwrite command with that of the sent-back data to confirm whether or not it has been changed.

Then, if the comparison is done at **Start Point**, **Mid-Point** and **Downstop Point**, confirm the first 4-digit number eliminating the last digit.

Example: In case of 12345" (123.45mm) at **Start Point**, eliminate the last digit 5" to confirm "1234" (123.4 mm).

Readout Command

Item	ORDER	CHACTER TRAIN	DESCRIPTION	RANGE
01	01-01	#	Communication start from host	Fixed
02	02-03	01	Communication ID	Fixed
03	04-04	R	Readout request	Fixed
04	05-07	nnn	Schedule Number	001 to 031
05	08-08	*	All contents	Fixed
06	09-09	$_{R}^{C}$	CR code (0 x 0D)	Fixed
07	10-10	$_{F}^{L}$	LF code (0 x 0A)	Fixed

Controller ➔ Host Computer

Item	ORDER	CHACTER TRAIN	DESCRIPTION	RANGE
01	01-01	!	Communication start to host	Fixed
02	02-03	01	Communication ID	Fixed
03	04-06	nnn	Schedule Number	001 to 031
04	05-07	:	Data Start	Fixed
05	08-13	nnnnn,	Start Point	00000 ➔ 05000 (nnn.nn dimensions in mm)
06	14-19	nnnnn,	Mid-Point	00000 ➔ 05000 (nnn.nn dimensions in mm)
07	20-25	nnnnn,	Downstop Point	00000 ➔ 05000 (nnn.nn dimensions in mm)
08	26-27	n,	Moving Speed between Start Point and Mid-Point	1 ➔ 8
09	28-29	n,	Moving Speed between Weld Point and Mid-Point	1 ➔ 8
10	30-32	n,	Hold Time	1 ➔ 8
11	32-33	n,	Moving Speed between Mid- Point and Weld Point	1 ➔ 4
12	34-34	n,	Additional Squeeze Time at Weld Point	1 ➔ A
13	35-35	$^{C}_{R}$	CR code (0 x 0D)	Fixed
14	36-36	$^{L}_{F}$	LF code (0 x 0A)	Fixed

Overwrite Command

Controller

Item	ORDER	CHACTER TRAIN	DESCRIPTION	RANGE
01	01-01	#	Communication start from host	Fixed
02	02-03	01	Communication ID	Fixed
03	04-04	w	Overwrite request	Fixed
04	05-07	nnn	Schedule Number	001 to 031
05	08-08	:	Data Start	Fixed
06	09-14	nnnnn,	Start Point	00000 ➔ 05000 (nnn.nn dimensions in mm)
07	15-20	nnnnn,	Mid-Point	00000 ➔ 05000 (nnn.nn dimensions in mm)
08	21-26	nnnnn,	Downstop Point	00000 ➔ 05000 (nnn.nn dimensions in mm)
09	27-28	n,	Moving Speed Between Start Point and Mid-Point	1 ➔ 8
10	29-30	n,	Moving Speed Between Weld Point and Mid-Point	1 ➔ 8
11	31-32	n,	Hold Time	1 ➔ 8
12	33-34	n,	Moving Speed between Mid- Point and Weld Point	1 ➔ 4
13	35-35	n,	Additional Squeeze Time at Weld Point	1 ➔ A
14	36-36	$^{C}_{R}$	CR code (0 x 0D)	Fixed
15	37-37	$^{L}_{F}$	LF code (0 x 0A)	Fixed

Controller ➔ Host Computer

Item	ORDER	CHACTER TRAIN	DESCRIPTION	RANGE
01	01-01	!	Communication Start to host	Fixed
02	02-03	01	Communication ID	Fixed
03	04-06	nnn	Schedule Number	001 to 031
04	07-07	:	Data Start	Fixed
05	08-13	nnnnn,	Start Point	00000 ➔ 05000 (nnn.nn dimensions in mm)
06	14-19	nnnnn,	Mid-Point	00000 ➔ 05000 (nnn.nn dimensions in mm)
07	20-25	nnnnn,	Downstop Point	00000 ➔ 05000 (nnn.nn dimensions in mm)
08	26-27	n,	Moving Speed between Start Point and Mid-Point	1 ➔ 8
09	28-29	n,	Moving Speed between Weld Point and Mid-Point	1 ➔ 8
10	30-31	n,	Hold Time	1 ➔ 8
11	32-33	n,	Moving Speed between Mid- Point and Weld Point	1 ➔ 4
12	34-34	n,	Additional Squeeze Time at Weld Point	1 ➔ A
13	35-35	$^{C}_{R}$	CR code (0 x 0D)	Fixed
14	36-36	$^{L}_{F}$	LF code (0 x 0A)	Fixed

APPENDIX E
ACCESSORIES

Accessories

Description	Model 71	Model 72
Electrodes	ES0402	EU1000
Operator Manual	*Operator Manual for the Series 70 Weld Heads* (990-143)	

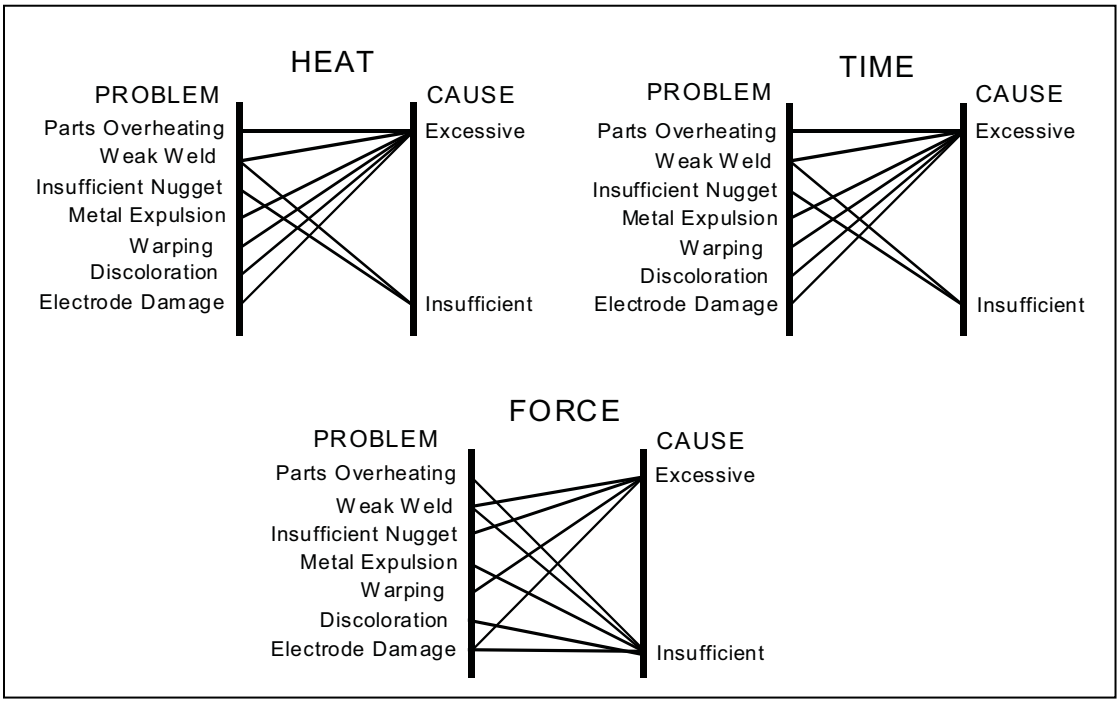
APPENDIX F
THE BASICS OF RESISTANCE WELDING

Resistance Welding Parameters

Resistance welding heat is produced by passing electrical current through the parts for a fixed time period. The welding heat generated is a function of the magnitude of the weld current, the electrical resistance of the parts, the contact resistance between the parts, and the weld force applied to the parts. Sufficient weld force is required to contain the molten material produced during the weld. However, as the force is increased, the contact resistance decreases. Lower contact resistance requires additional weld current, voltage, or power to produce the heat required to form a weld.

The higher the weld force, the greater the weld **current**, **voltage**, **power**, or **time** required to produce a given weld. The formula for amount of heat generated is $\mathbf{I^2RT}$ -- the square of the weld current [**I**] times the workpiece resistance [**R**] times the weld time [**T**].

Welding Parameter Interaction



Interaction of Welding Parameters

Electrode Selection

Correct electrode selection strongly influences how weld heat is generated in the weld area. In general, use conductive electrodes such as a RWMA-2 (Copper alloy) when welding electrically resistive parts such as nickel or steel so that the weld heat is generated by the electrical resistance of the parts and the contact resistance between the parts. Use resistive electrodes such as RWMA-13 (Tungsten) and RWMA-14 (Molybdenum) to weld conductive parts such as copper and gold because conductive parts do not generate much internal heat so the electrodes must provide external heat. Use the following Electrode Selection Table for selecting the proper electrode materials.

MATERIAL	ELECT RWMA TYPE	MATERIAL	ELECT RWMA TYPE
Alumel	-2	Alumel	-2
Alumel	-2	Chromel	-2
Alumel	-2	Dumet	-2
Aluminum	-1	Aluminum	-1
Aluminum	-1	Aluminum Alloys	-1
Aluminum	-1	Cadmium Plating	-1
Aluminum	-1	Tinned Brass	-14
Aluminum	-1	Tinned Copper	-14
Aluminum	-1	Gold Plated Dumet	-2
Aluminum	-1	Gold Plated Kovar	-2
Aluminum	-1	Kovar	-2
Aluminum	-1	Magnesium	-1
Aluminum	-1	Cold Rolled Steel	-2
Aluminum	-1	Stainless Steel	-2
Beryllium Copper	-2	Beryllium Copper	-2
Beryllium Copper	-2	Brass	-2, -14
Beryllium Copper	-2	Copper	-14
Beryllium Copper	-2	Tinned Copper	-14
Beryllium Copper	-2	Nickel	-2

MATERIAL	ELECT RWMA TYPE	MATERIAL	ELECT RWMA TYPE
Beryllium Copper	-2	Cold Rolled Steel	-2
Beryllium Copper	-2	Stainless Steel	-2
Brass	-2, -14	Brass	-2, -14
Brass	-2, -14	Tinned Brass	-14
Brass	-2, -14	Consil	-2
Brass	-2, -14	Constantan	-2
Brass	-2, -14	Copper	-14
Brass	-2, -14	Tinned Copper	-14
Brass	-2, -14	Dumet	-2
Brass	-2, -14	Nichrome	-2
Brass	-2, -14	Nickel	-2
Brass	-2, -14	NiSpan C	-2
Brass	-2, -14	Paliney 7	-2
Brass	-2, -14	Silver	-11, -14
Brass	-2, -14	Cold Rolled Steel	-2
Brass	-2, -14	Stainless Steel	-2
Bronze	-2, -11	Bronze	-2, -11
Bronze	-2, -11	Tinned Copper	-14
Bronze	-2, -11	Iron	-2
Bronze	-2, -11	Nichrome	-2
Bronze	-2, -11	Nickel	-2
Chromel	-2	Chromel	-2
Chromel	-2	Constantan	-2
Chromel	-2	Copel	-2
Chromel	-2	Copper	-14

MATERIAL	ELECT RWMA TYPE	MATERIAL	ELECT RWMA TYPE
Chromel	-2	Tinned Copper	-14
Chromel	-2	Dumet	-2
Chromel	-2	Nichrome	-2
Chromel	-2	Cold Rolled Steel	-2
Consil	-2	Consil	-2
Consil	-2	Tinned Copper	-14
Consil	-2	Dumet	-2
Constantan	-2	Constantan	
Constantan	-2	Copper	-14
Constantan	-2	Tinned Copper	-14
Constantan	-2	Iron	-2
Constantan	-2	Nichrome	-2
Constantan	-2	Nickel	-2
Copper	-14	Copper	-14
Copper	-14	Dumet	-2
Copper	-14	Invar	-2
Copper	-14	Karme	-2
Copper	-14	Manganin	-2
Copper	-14	Nichrome	-2
Copper	-14	Nickel	-2
Copper	-14	Paliney 7	-2
Copper	-14	Silver	-11, -14
Copper	-14	Cold Rolled Steel	-2
Copper	-14	Stainless Steel	-2
Dumet	-2	Dumet	-2
Dumet	-2	Nichrome	-2
Dumet	-2	Nickel	-2
Dumet	-2	Platinum	-2
Dumet	-2	Cold Rolled Steel	-2
Evanohm	-14	Copper	-14
Gold	-14	Gold	-14
Gold	-14	Kovar	-2
Hastalloy	-2	Titanium	-2
Inconel	-2	Inconel	-2
Inconel	-2	Kulgrid	-2

MATERIAL	ELECT RWMA TYPE	MATERIAL	ELECT RWMA TYPE
Invar	-2	Invar	-2
Iridium	-2	Iridium	-2
Iridium	-2	Platinum	-2
Iron	-2	Iron	-2
Karma	-2	Karma	-2
Karma	-2	Nickel	-2
Karma	-2	Platinum	-2
Kovar, Gold Plate	-2	Kovar, Gold Plate	-2
Kovar, Gold Plate	-2	Kulgrid	-2
Kovar, Gold Plate	-2	Nickel	-2
Kovar, Gold Plate	-2	Silver	-11, -14
Kovar, Gold Plate	-2	Stainless Steel	-2
Magnesium	-1	Magnesium	-1
Molybdenum	-2	Molybdenum	-2
Molybdenum	-2	Nickel	-2
Molybdenum	-2	Tungsten	-2
Nichrome	-2	Nichrome	-2
Nichrome	-2	Nickel	-2
Nichrome	-2	Cold Rolled Steel	-2
Nichrome	-2	Stainless Steel	-2
Nickel	-2	Nickel	-2
Nickel	-2	Cold Rolled Steel	-2
Nickel	-2	Stainless Steel	-2
Nickel	-2	Tantalum	-2
Nickel	-2	Tungsten	-2
Nickel Alloy	-2	Nickel Alloy	-2
Nickel Alloy	-2	Tinned Brass	-14
Nickel Alloy	-2	Beryllium Copper	-2
Nickel Alloy	-2	Consil	-2
Nickel Alloy	-2	Tinned Copper	-14
Nickel Alloy	-2	Nichrome	-2
Nickel Alloy	-2	Nickel	-2
Nickel Alloy	-2	Cold Rolled Steel	-2
NiSpan C	-2	NiSpan C	-2
NiSpan C	-2	Cold Rolled Steel	-2

MATERIAL	ELECT RWMA TYPE	MATERIAL	ELECT RWMA TYPE
NiSpan C	-2	Stainless Steel	-2
Niobium	-2	Niobium	-2
Platinum	-2	Platinum	-2
Paliney 7	-2	Paliney 7	-2
Silver	-11, -14	Silver	-11, -14
Silver	-11, -14	Cadmium	-13
Silver	-11, -14	Cold Rolled Steel	-2
Silver	-11, -14	Stainless Steel	-2
Cold Rolled Steel	-2	Cold Rolled Steel	-2

MATERIAL	ELECT RWMA TYPE	MATERIAL	ELECT RWMA TYPE
Cold Rolled Steel	-2	Stainless Steel	-2
Cold Rolled Steel	-2	Tantalum	-2
Stainless Steel	-2	Stainless Steel	-2
Stainless Steel	-2	Tungsten	-2
Tantalum	-2	Tantalum	-2
Titanium	-2	Titanium	-2
Tungsten	-2	Tungsten	-2
Tungsten	-2	henium	-2
Zinc	-14	Zinc	-14

Electrode Maintenance

Depending on use, periodic tip resurfacing is required to remove oxides and welding debris from electrodes. Cleaning of electrodes on production line should be limited to use of #400-600 grit electrode polishing disks. For less critical applications, a file can be used to clean a badly damaged tip. However, after filing, polishing disks should then be used to ensure that the electrode faces are smooth. If this is not done, the rough surface of the electrode face will have a tendency to stick to the work piece.

Weld Schedule Development

Developing a weld schedule is a methodical procedure, which consists of making sample welds and evaluating the results. The first weld should be made at low energy settings. Adjustments are then made to each of the welding parameters ***one at a time*** until a successful weld is made.

1 Install the correct electrodes in the electrode holders on the Weld Head. See the preceding Table for electrode material recommendations.

2 Use a flat electrode face for most applications. Use a "domed" face if surface oxides are a problem. If either of the parts is a wire, the diameter of the electrode face should be equal to or greater than the diameter of the wire. If both parts are flat, the face should be at least one-half the diameter of the electrodes. Pencil point electrodes cause severe electrode sticking to the parts, unexplained explosions, and increase the weld heat substantially because of the reduced electrode-to-part contact area.

3 Use the Force Adjustment Knob on the Weld Head to set the Firing Force and adjust an Air Actuated Weld Head.

4 Program a weld schedule, then make your first weld. Always observe safety precautions when welding and wear safety glasses. For a complete procedure on making welds, refer to *Chapter 4, Operating Instructions*.

5 Use pliers to peel the welded materials apart. A satisfactory weld will show residual material pulled from one material to the other. Tearing of base material around the weld nugget indicates a material failure NOT a weld failure. Excessive electrode sticking and/or "spitting" should define a weld as unsatisfactory and indicates that too much weld current, voltage, power, or time has been used.

6 If the parts pull apart easily or there is little or no residual material pulled, the weld is weak. Increase the weld time in 1 msec increments. Increase weld current, voltage, or power if a satisfactory weld achieved using 10 msec of weld time.

NOTE: Actual weld strength is a user-defined specification.

7 Polarity, as determined by the direction of weld current flow, can have a marked effect on the weld characteristics of some material combinations. This effect occurs when welding materials with large differences in resistivity, such as copper and nickel or when welding identical materials with thickness ratios greater than 4 to 1. The general rule is that the more resistive material or the thinner material should be placed against the negative (-) electrode. Polarity on the Control can only be changed by reversing the Weld Cables.

Weld Strength Testing

Destructive tests should be performed on a random basis using actual manufacturing parts. Destructive tests made on spot welds include tension, tension-shear, peel, impact, twist, hardness, and macro-etch tests. Fatigue tests and radiography have also been used. Of these methods torsional shear is preferred for round wire and a 45-degree peel test for sheet stock.

Weld Strength Profiles

Creating a weld strength profile offers the user a scientific approach to determining the optimum set of welding parameters and then displaying these parameters in a graphical form.

1 Start at a low weld current, voltage, or power, making five or more welds, then perform pull tests for each weld. Calculate the average pull strength. Increase weld current, voltage, or power and repeat this procedure. Do not change the weld time, weld force, or electrode area.

2 Continue increasing weld current, voltage, or power until any unfavorable characteristic occurs, such as sticking or spitting.

3 Repeat steps 1 through 3 for different weld forces, then create a plot of part pull strength versus weld current, voltage, or power for different weld forces as shown in the illustration on the next page, *Typical Weld Strength Profile*.

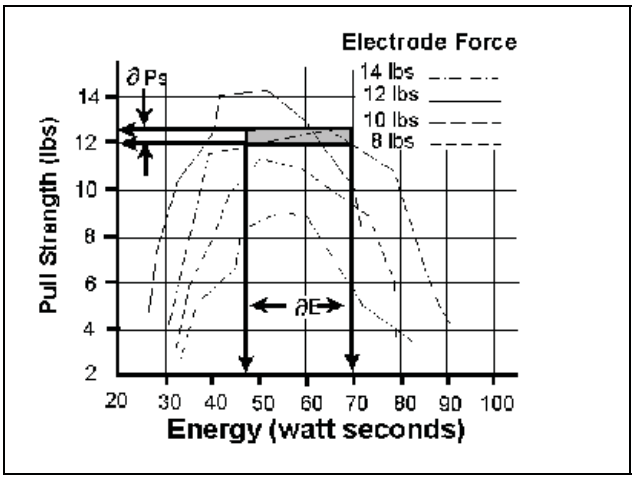
4 Repeat steps 1 through 3 using a different but fixed weld time.

Typical Weld Strength Profile

The picture on the right illustrates a typical weld strength profile. The 14 lb electrode force curve shows the highest pull strengths but the lowest tolerance to changes in weld current, voltage, or power. The 12 lb electrode force curve shows a small reduction in pull strength, but considerably more tolerance to changes in weld energy. Weld heat will vary as a result of material variations and electrode wear.

The 12 lb electrode force curve is preferred. It shows more tolerance to changes in weld current, voltage, or power and has nearly the same bond strength as the 14 lb electrode force curve.

A comparison of weld schedules for several different applications might show that they could be consolidated into one or two weld schedules. This would have obvious manufacturing advantages.



Typical Weld Strength Profile

APPENDIX G

Quality Resistance Welding Solutions Defining the Optimum Process

Introduction

A quality resistance welding solution can be defined as one that meets the application objectives and produces stable, repeatable results in a production environment. In order to define the optimum process the user must approach the application in a methodical way and many variables must be considered. In this article we will look at the following key stages and principles to be considered when defining the optimum resistance welding process:

- Materials and their properties
- Basic resistance welding principles
- Weld profiles
- Approach to development
- Common problems
- Use of screening DOE'S
- Use of factorial DOE'S

Resistance Welding - A Material World

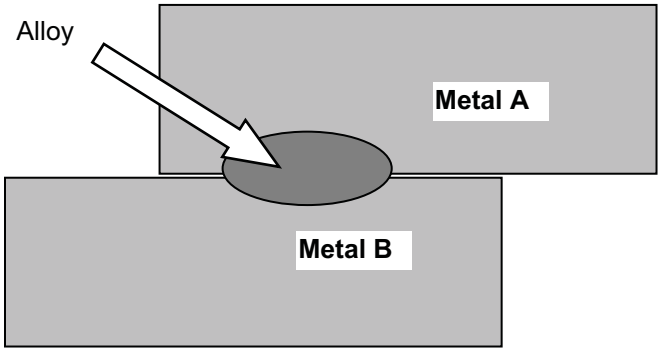
The first stage in designing a quality welding solution is to consider the properties of the materials to be joined and also the quality requirements of the desired welded joint. When considering these properties it is worthwhile to review the way the resistance welding process works and the likely outcome when the parts are resistance welded.

There are four main types of structural materials:

- Metals: silver, steel, platinum
- Ceramic: alumina, sand
- Plastics / polymers: PVC, teflon
- Semiconductors: silicon, geranium

Metals can be resistance-welded because they are electrically conductive, soften on heating, and can be forged together without breaking.

Alloys are a mixture of two or more metals as shown on the right. Alloys are normally harder, less conductive, and more brittle than the parent metal. This has bearing on the type of joint one can expect when resistance-welding a combination of different metals.



Metals atoms are naturally attracted to other metal atoms even in different parent materials. Metals and alloys will bond together once surface contaminants such as dirt grease and oxides are removed. Resistance welding generates heat at the material interface that decomposes the dirt and grease and helps to break up the oxide film. The heat generated softens or melts the metal and the applied force brings the atoms on either side into close contact to form the bond. The strength of the joint develops as the joint cools and a new structure is formed.

There are three main types of bonds that can be formed using the resistance welding process:

- **A Solder or Braze Joint**
  A filler material such as a solder or braze compound is either added during the process or present as a plating or coating. Soldered joints are typically achieved at temperatures less than 400°C and brazed joints such as Sil-Phos materials melt at temperatures above 400°C.
- **A Solid-State Joint**
  A solid state joint can be formed when the materials are heated to between 70-80% of their melting point.
- **A Fusion Joint**
  A fusion joint can be formed when both metals are heated to their melting point and their atoms mix.

Many micro resistance-welding challenges involve joining dissimilar metals in terms of their melting point, electrical conductivity, and hardness. A solid-state joint can be an ideal solution for these difficult joining challenges. There is no direct mixing of the two materials across the weld interface thus preventing the formation of harmful alloys that could form brittle compounds that are easily fractured. In a solid-state joint the metals are only heated to 70-80% of their respective melting points. This means that the materials are less thermally stressed during heating and subsequent joint cooling in comparison to a fusion weld. As there is no real melting of the materials in a solid-state joint there is less chance of weld splash or material expulsion. A weld nugget can still be achieved with a solid-state joint.

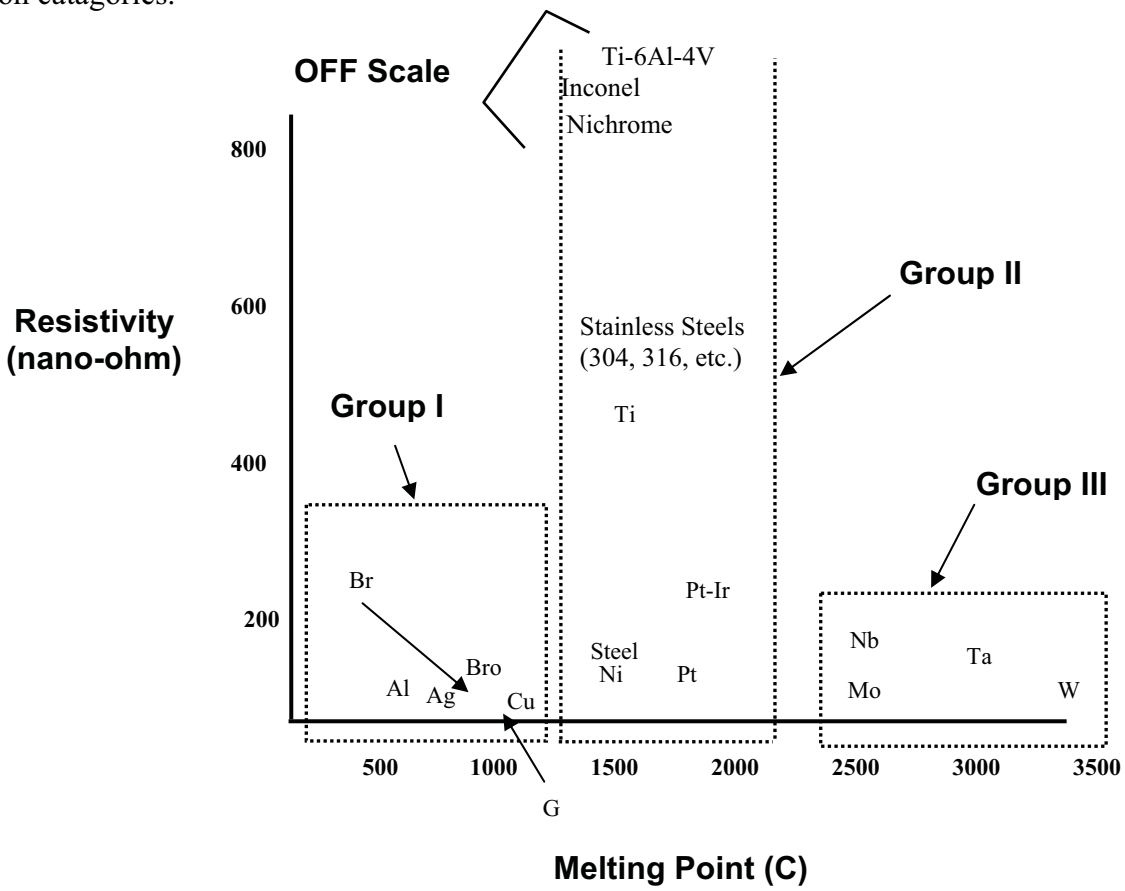
Consider the Material Properties

The important material properties to be considered in the resistance welding process are as follows:

- Electrical and thermal conductivity
- Melting point
- Hardness

It is also important to consider the surface properties of each material such as plating, coatings, and oxides.

The figure below gives an idea of the variance in resistivity and melting point for some of the more common materials used today in micro resistance welding. The materials can be grouped into three common catagories.



The types of joints achievable within each of the main groups are as follows:

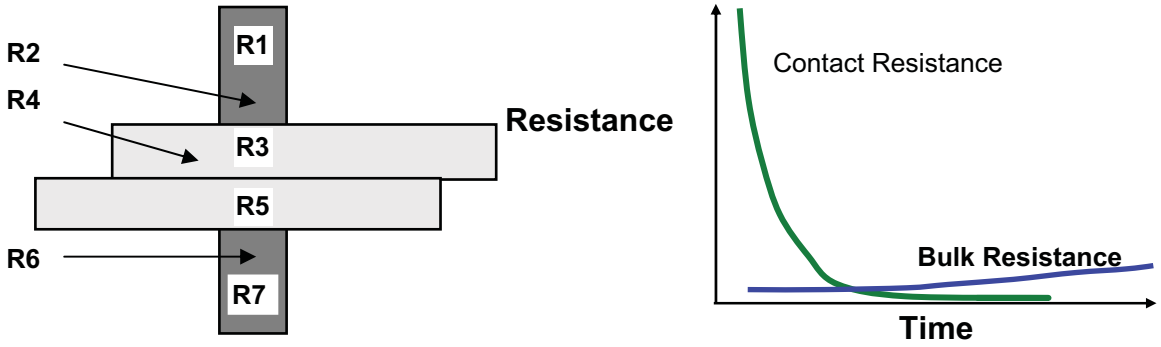
- **Group I – Conductive Metals**
  - Conductive metals dissipate heat and it can also be difficult to focus heat at the interface. A solid-state joint is therefore preferred. Typically resistive electrode materials are used to provide additional heating.

- **Group II – Resistive Metals**
  - It is easier to generate heat and trap heat at the interface of resistive metals and therefore it is possible to form both solid state and fusion welds depending on the time and temperature. Upslope can reduce contact resistances and provide heating in the bulk material resistance.
- **Group III – Refractory Metals**
  - Refractory metals have very high melting points and excess heating can cause micro-structural damage. A solid-state joint is therefore preferred.

The chart below gives some guidance on the type of joint that can be expected and design considerations required when joining materials from the different groups.

	Group I	Group II	Group III
Group I (Copper)	• Solid-State • W/Mo electrodes	• Solid-State • Projection on Group I	• Solid-State • Fine projections on Group III
Group II (Steel)		• Solid-State or Fusion	• Solid-state or braze of II on III • Projection on III
Group III (Moly)			• Solid-State

Basic Principles



The figure above shows the key resistances in a typical opposed resistance weld and the relationship between contact resistances and bulk resistances over time, during a typical resistance weld.

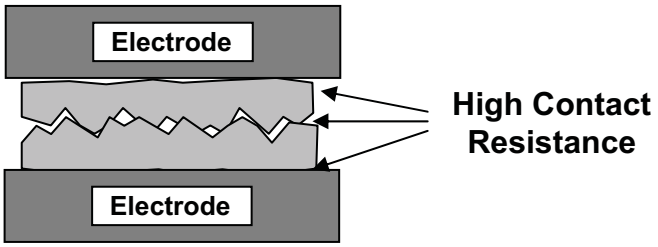
R1 & R7 The electrode resistances affect the conduction of energy and weld heat to the parts and also the rate of heat sinking from the parts at the end of the weld.

R2, R4 & R 6 The electrode to part and part to part **"Contact Resistances"** determine the amount of heat generation in these areas. The contact resistances decline over time as the parts achieve better fit up.

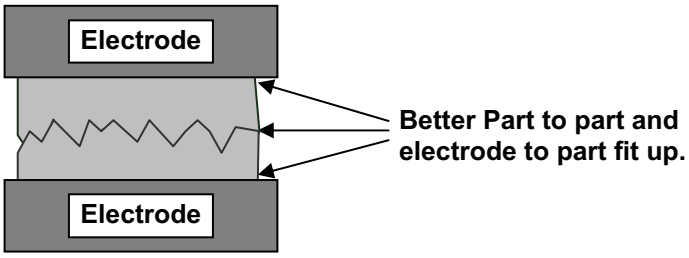
R3 & R5 The metal **"Bulk Resistances"** become higher during the weld as the parts are heated.

If a weld is initiated when the contact resistances are still high, the heat generated is in relation to the level and location of the contact resistances, as the materials have not had a chance to fit up correctly. It is common for the heat generated at the electrode to part and part to part resistances to cause multiple welding problems when welding resistive materials (see below). Conductive materials can be welded by using high contact resistance and fast heating as their bulk resistance is not high and cannot be relied upon for heat generation.

- Part marking and surface heating
- Weld splash or expulsion
- Electrode sticking
- Weak welds



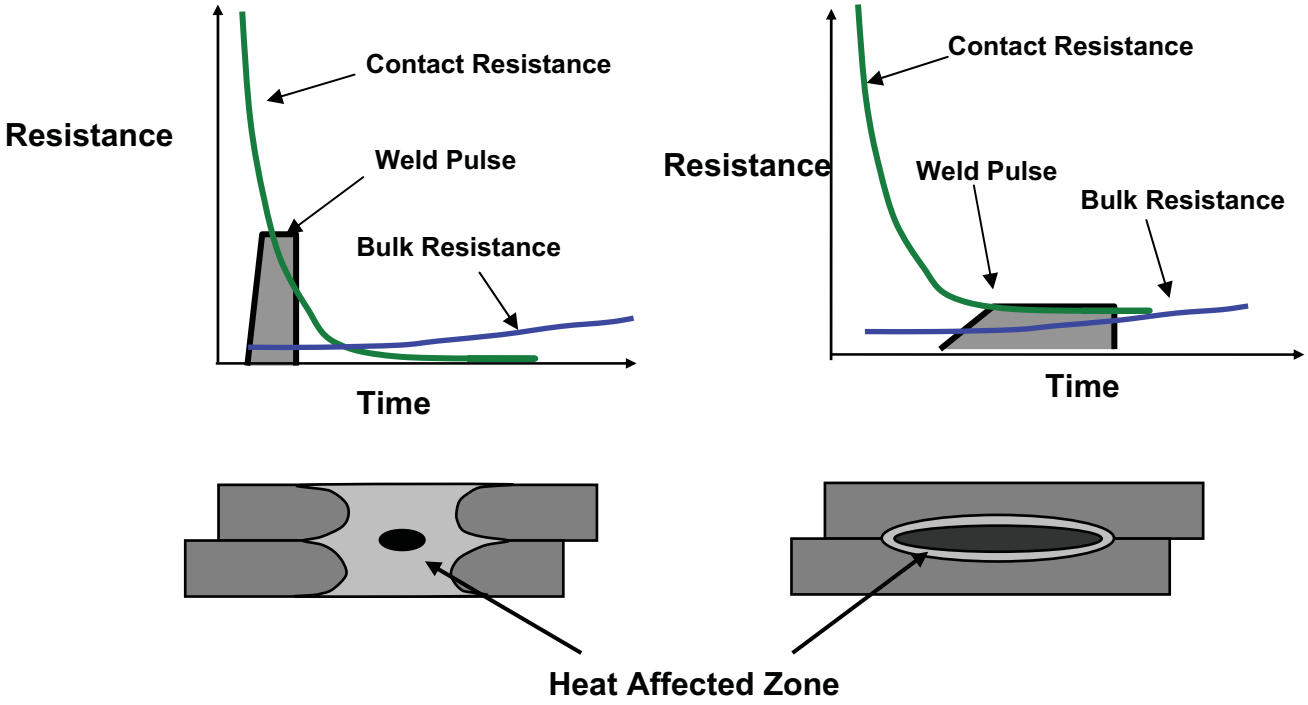
If a weld is initiated when both parts and electrodes are fitted up correctly as show on the right, the contact resistance is lower and bulk resistance now controls the heat generation. This type of weld is achieved with a slower heating rate and normally longer time is preferred for welding resistive materials which can generate heat through their bulk resistance.



The contact resistance present at the weld when the power supply is fired has a great impact on the heat balance of a weld and therefore also the heat affected zone.

The figure below shows a weld that is fired early on in the weld sequence when the contact resistance is still quite high.

The figure below shows a weld that is initiated when the contact resistance is lower and in this example we are using bulk resistance to generate our weld heat.

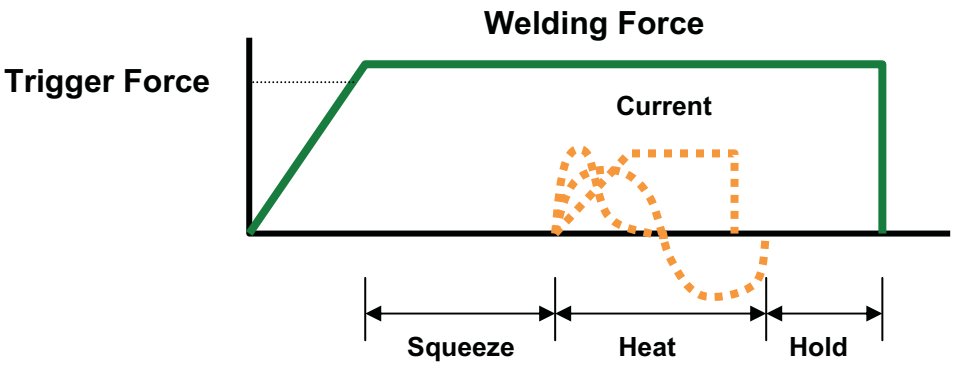


(NOTE: Larger nuggets are possible with longer weld times when using bulk resistance.)

In general conductive materials benefit from a faster heating rate, as the higher contact resistances assist heat generation in the weld. Resistive materials benefit from slower heating rates that allow the contact resistances to reduce significantly thus bulk resistances become the major source for heat generation.

Weld Profiles

The basic welding profile or schedule consists of a controlled application of energy and force over time. Precision power supplies control the energy, time, and therefore heating rate of the parts. The weld head applies force from the start to finish of the welding process.



The figure on the right shows a typical welding sequence where the force is applied to the parts; a squeeze time is then initiated which allows the force to stabilize before the current is fired. Squeeze time also allows time for the contact resistances to reduce as the materials start to come into closer contact at their interface. A hold time is the initiated after current flows to allow the parts to cool under pressure before the electrodes are retracted from the parts. Hold time is important as weld strength develops in this period of time. This basic form of weld profile is sufficient for the majority of small part resistance welding applications.

Power supply technology selection is based on both the requirements of the application and process. In general, closed loop power supply technologies are the best choice for their consistent, controlled output and fast response to changes in resistance during the weld (for further details, see the Unitek Peco "slide rule").

Approach to Weld Development

The first stage in developing a quality welding process is to fix as many of the variables as possible in the welding equipment set up. The welding variables can be grouped in the following categories:

- **Material variables**
  - Base material
  - Plating
  - Size
  - Shape
- **Weld head & mechanical variables**
  - Force, squeeze, hold
  - Actuation method
  - Electrode material and shape
- **Power supply variables**
  - Energy
  - Time (squeeze, weld, hold)
- **Process variables**
  - Tooling, level of automation
  - Repetition rate
  - Part positioning
  - Maintenance, electrode cleaning
- **Quality requirements**
  - Pull strength
  - Visual criteria
  - Test method, other weld joint requirements

At this stage, it is good practice to document the welding set up so that it can be referred to later (request Unitek Peco "Process Audit Worksheet" for an example). Once the equipment set up has been documented the next stage is to fix as many of the process and material variables as possible to reduce variation in the subsequent welding trials. The main welding parameters such as energy, force, and time cannot be fixed at this stage but many of the other variables such as repeatable part positioning should be fixed.

Initial Welding Trials -- The "Look See" Tests

"Look see" welding tests are a series of mini welding experiments designed to provide a starting point for further statistical development of the welding parameters. The user should adjust the key welding variables (energy, force, time) in order to identify the likely good "weld window".

The mini experiments should also be used to understand the weld characteristics from both application and process perspective. Key factors in this understanding are listed on the next page.

Application Perspective

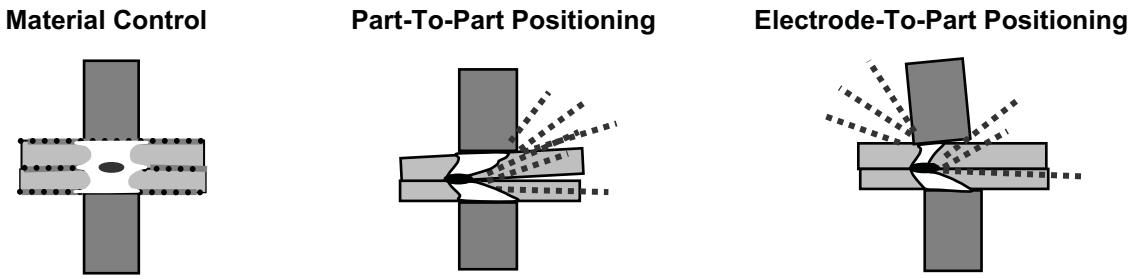
- Materials: Resistivity, melting point, thermal mass
- Shape, hardness
- Heat balance: Electrode materials, shape
- Polarity, heating rate (upslope)
- Observation: visual criteria, cross section, and impact of variables on heat balance

Process Perspective

- What are the likely variables in a production process?
- How will operators handle and align the parts?
- What tooling or automation will be required?
- How will operators maintain and change the electrodes?
- What other parameters will operators are able to adjust?
- What are the quality and inspection requirements?
- What are the relevant production testing methods and test equipment?
- Do we have adequate control over the quality of the materials?

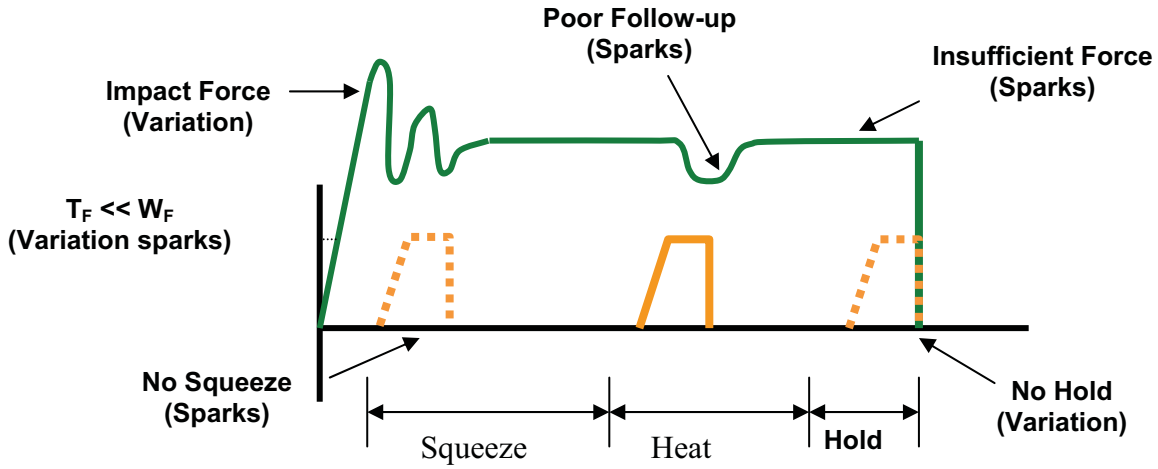
Common Problems

During this stage of process development it is important to understand that the majority of process problems are related to either materials variation, or part to electrode positioning. Some examples are shown below.



The changes detailed above generally result in a change in contact resistance and always affect the heat balance of the weld. During weld development these common problems must be carefully monitored so as not to mislead the course and productivity of the welding experiments.

In summary the "look see" welding experiments should be used to fix further variables from an application and process perspective and also to establish a "weld window" for energy, time and force. This part of weld development is critical in order to proceed to a statistical (Design of Experiments) method of evaluation. Random explosions or unexpected variables will skew statistical data and waste valuable time.



The figure above shows common welding problems that can often be identified in the basic set up of the force, energy and time welding profile. These problems can lead to weld splash and inconsistency and variation (contact Unitek Peco for further information and support).

What are Screening DOE'S?

The purpose of a Screening DOE (Design of Experiments) is to establish the impact that welding and process parameters have on the quality of the weld. Quality measurement criteria should be selected based on the requirements of the application. A Screening DOE will establish a relative quality measurement for the parameters tested and also the variation in the welded result. This is important, as variation in process is critical in establishing the best production settings.

Typical welded assemblies are assessed for strength of joint and variation in strength. A Screening DOE tests the high and low settings for a parameter, and will help establish the impact of a parameter on the process. A Screening DOE is a tool that allows the user to establish the impact of a particular parameter by carrying out the minimum number of experiments to gain the information.

A five-factor screening DOE can be accomplished in as few as 24 welds with three welds completed for each of 8 tests. By comparison, it would take 96 welds to test every combination. It promotes understanding of many variables in a single experiment and allows the user to interpret results and thus narrow the variables for the next level of statistical analysis. If many variables are still not understood, multiple Screening DOE'S may be required. Unitek Peco provides a simple Screening DOE tool that is run in excel and is sufficient for the majority of applications (contact us for details). Bespoke sophisticated software is also available from other vendors designed specifically for this purpose.

Criteria for Success

Before running the series of experiments, the user must establish an acceptable window for energy, time, and force. This will prevent voided results. It is common practice to include one or all of the above variables in a Screening DOE. This is only recommended if sufficient understanding has been established for the other application and process variables that can impact quality. Users should first try to screen out all common application and process variables that require further exploration from the results of the "look see" mini experiments and then include the three key welding variables (energy, force and time). Several Screening DOE'S maybe required.

Results should be interpreted carefully. Typically one would look for the highest result in terms of quality with the least variation. A Screening DOE provides only a measurement that indicates the relative importance of a parameter and not the ideal setting. Factorial DOE'S should be used to establish the correct or best setting for a parameter once many of the other variables have been screened and fixed. This is the time to also assess the measurement accuracy and consistency of the test method and procedure. Variation in test method can invalidate the test and can lead to misinterpretation of results.

What are Factorial DOE'S?

The purpose of a Factorial DOE is to narrow in on the optimal setting for a particular parameter. This method is generally used when the critical or main key variables have been identified and we need to establish the best settings for the process. A factorial DOE may also give an indication as to how wide the acceptable weld window is in relation to quality requirements. We recommend data be gathered from a monitoring perspective so that this can provide a starting point for establishing a relationship between quality and the monitored measurement parameter.

Criteria for Success

Critical parameters should be identified from the list of unfixed variables left from the Screening DOE'S. A mini experiment maybe required establishing reasonable bounds for the combination of parameters to be tested. This will prevent void data and wasted time. At this stage it is useful to record multiple relevant quality measurement or inspection criteria so that a balanced decision can be reached. For example if part marking and pull strength are the relevant criteria, a compromise in ideal setting maybe required.

As with all experiments the test method should be carefully assessed as a potential source of variation and inconsistency. Once the optimum parameters have been established in this series of experiments, a validation study can be run which looks at the consistency of results over time. It is good practice to build in variables such as electrode changes and cleaning, as well as equipment set up by different personnel to ensure that the solution is one that can run in a real production environment. Welded assemblies should be tested over time an under real use conditions to ensure that all functionality criteria will be met. Validation testing is usually required to prove the robustness of the process under production conditions.

Conclusion

The resistance welding process can deliver a reliable and repeatable joining solution for a wide range of metal joining applications. Defining the optimum welding process and best production settings is not a "black art" and can be achieved through a methodical and statistical approach. Time spent up-front in weld development will ensure a stable welding process and provide a substantial return in quality and long term consistency. Welding problems can more easily be identified and solved if sufficient experimental work is carried out to identify the impact of common variables on the quality and variation of the welded assembly. Unitek Peco will frequently use the Screening DOE tool to establish the impact of key variables and also to assist customers with troubleshooting. Often the testing as described above will provide the information and understanding to predict common failure modes and causes. A troubleshooting guide can be requested in the form of a slide rule to assist users in identification of welding problems and likely causes.